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THE ALCHEMIST, 18TH CENTURY (FRENCH SCHOOL).—*Signed* J. H.

EDITOR'S OUTLOOK

WE ARE indebted to the Monsanto Chemical Works of St. Louis, Mo., for their kindness in furnishing us, through Mr. R. E. Sturhahn, with the picture for this month's frontispiece.

The Alchemist

This painting shows an alchemist testing his supposed discovery, "Elixir of Eternal Youth," which, however, proves to be a myth, as is evident by the explosion of the apparatus and consequent effect upon his assistants. "Father Time," jealous of such attempts upon his own particular domain, remonstrates with the alchemist, and is in the act of placing a fool's cap upon his head, cautioning that "all things must die."

Figuratively, the goal of the alchemist—the transmutation of base matter into gold—has been realized. What wealth has chemistry found in coal tar, for instance. And in the products of our pharmaceutical laboratories have we not the means of restoring health—the alchemist's "Elixir of Eternal Youth?" With its countless contributions to the safety, comfort and beauty of life, is not chemistry accomplishing all that the alchemist hoped from his mythical philosopher's stone?

IT MIGHT seem to be a reasonable assumption that one trained in the scientific method and convinced of its efficacy would automatically exhibit some regard for its precepts and spirit in all his activities. More

Cobblers' Children

particularly, one might feel safe in assuming that teachers of science, desirous of transmitting to their pupils an understanding and appreciation of the method of science, would naturally regulate their methods of instruction in accordance with it.

In the light of some of the discussions which took place at the Los Angeles meeting, however, it becomes evident that such optimistic assumptions are not universally justified by facts. There were definite indications, even, that some few teachers at least had no clear conception of what the use of the scientific method in teaching might imply.

Briefly, the technique of science, in the extension and organization of knowledge, consists in a rational procedure from the known to the unknown—the induction of new generalizations from known particulars or the deduction of new particulars from proven generalizations (with, of course, proper experimental inquiry and verification). The student can most efficiently acquire new knowledge and most thoroughly and permanently incorporate it into his consciousness by means of the same system. If you doubt it, compare the effort expended in memorizing some short poem with that necessary to master an equal number of words picked at

random from the dictionary. When you have learned both, see which you can remember longer.

Then why not teach with these considerations in mind? After all, what is teaching if it is not helping the student to learn?

Some solemn and literal-minded individual will undoubtedly arise at this point to protest that it is preposterous to have a student perform all the experiments upon which our present laws of science are founded and so, in effect, compel him to discover them for himself. He will go on to add that many of the steps leading up to the established laws and theories of chemistry would be unintelligible and confusing to a beginner anyway. What is the use of instruction, he will conclude, if it requires the student to rediscover and prove the sum of all past knowledge?

No one advocates any such burlesque. It is, however, neither preposterous nor impossible to so direct a pupil's learning that what he learns today shall make sense with what he learned yesterday and with what he observes every day in the world about him.

We hope to turn out pupils who are purposeful, self-reliant, sincere, imaginative, open-minded, and disposed to follow truth wherever it may lead. Yet some of us immediately proceed to train them in all these admirable qualities by requiring them to passively and unimaginatively accept upon authority and memorize an apparently heterogeneous collection of facts which we consider essential. A sad commentary, indeed, upon our consistency and our sense of humor.

Noblesse Oblige

DR. LITTLE'S address before the American Institute of Chemical Engineers[1] was widely reported and commented upon and even found its way into the popular magazines.[2] Teachers who have not as yet read it should, by all means, do so. No less worthy of attention is the opening lecture which he delivered to the students at the recent Exposition of Chemical Industries and which appears in this issue of the JOURNAL. In both of these addresses he preaches the sound doctrine of industrial salvation through research.

In this connection it is encouraging to note the number of prominent chemists, with something worth saying and the gift of saying it effectively, who are devoting a portion of their time to the upbuilding of their profession. They are making a valuable contribution to the cause of chemical education and to chemistry in general. May their ranks increase.

[1] "The Handwriting on the Wall," *Ind. Eng. Chem.*, **17**, 857–8 (1925); *Chem. & Met. Eng.*, **32**, 672–3 (1925).

[2] *Lit. Digest*, **86**, *12*, 22–3 (Sept. 19, 1925).

The Essay Contest

NOTWITHSTANDING the fact that this year's essay contest has received less publicity than was accorded the previous ones, we are gratified to observe that teachers are more keenly interested than ever. In many schools and colleges the A. C. S. essay has become an integral part of the curriculum and teachers have arranged to excuse participants in the contest from other exercises designed to attain similar ends. There is also a growing tendency to seek a correlation of chemistry and English work to the effect that pupils may submit their essays as exercises in English and receive criticism and credit thereon.

In a contribution to the correspondence columns of this number, Professor Miller of Scranton High School discusses these and other plans for furthering the contest.

Reducing the Mental Mortality Rate

SOMEONE has elsewhere remarked the active resistance which the mind of the ordinary man offers to the entrance of ideas. This phenomenon is especially evident, as Dr. Slosson comments, when the idea is of such nature as to require "considerable rearrangement of the mental furniture before room can be found for it." When the acceptance of any particular idea, furthermore, carries with it the necessity for a radical departure from established custom and involves extra thought and labor, then active resistance reaches its climax.

Observe how the impervious mind reacts to the plea for a more equitable distribution of instruction and opportunity with reference to the capacity of the distributees. Many of us recognize the justice of the plea; probably we have always taken a keener interest in our more promising pupils; we feel that something more definite should be done. But now comes the apostle of things as they are, the complacent fatalist who, too often, lulls us back into the comfortable somnolence of inactivity. "Genius," he states with axiomatic finality, "cannot be suppressed. Exceptional ability will find an outlet in spite of difficulties and discouragements. It requires no pampering."

Before swallowing this soothing syrup, however, let us examine its composition in more detail. "Genius" appears to be the essential ingredient. What constitutes genius? One encounters a very reasonable doubt as to whether there is, in the commonly accepted sense of the word, any such thing at all. As ordinarily employed the term has a more or less mystical connotation. It implies in the world of the mind a something analogous to the mythical sixth sense in the physiological world. In short, genius, in the ordinary sense, is a composite one-word illustration of two well-known human traits—first, man's

serene satisfaction in a catchword which furnishes some sort of reply to a question, whether it answers that question or not; and, second, the inferior man's effort to preserve his self-esteem by attributing all evidences of superiority in others to supernatural endowment. (This latter characteristic is further manifested in the fiction of luck.)

If we study with care the lives and achievements of these men of genius, of what ability or gift, denied to ordinary men, do we find them possessed? Clearly, none. Their powers differ from those of ordinary men, if at all, in degree only. Frequently one is led to suspect that interest and application have enabled men of merely average intellect to achieve feats which have placed them among the immortals. Who, then, can say where, in all its innumerable gradations from the lowest to the highest, ability crosses the line that makes it forever independent of external stimulation or hindrance?

Being mindful of the unfailing facility with which figures, like Scripture, can be invoked in support of any theme, I hesitate to introduce evidence which has any appearance of the statistical, yet I cannot refrain from recording a circumstance (possibly coincidental) which, I find, has not been confined to my own observation. In the current number of *The Scientific Monthly*, appears an article by George P. Meade on "The Youthful Achievements of Great Scientists." To the conclusion of his dissertation, which deals with some fifty or sixty famous men of science, Mr. Meade appends this note:

"Throughout this study the writer has been impressed by the number of young scientists whose work has been influenced by some teacher or other person who encouraged and directed the youthful enthusiasm. 'His work attracted the attention of so-and-so.' 'At the university he came under the influence of the great so-and-so.' 'His father early recognized and fostered his ability.' 'To Professor ——— must be given much of the credit for his interest in the science.' These and similar phrases occur with noticeable regularity in the encyclopedias and biographical works from which the data for this article have been gained. It must follow that the opposite is true, that many early enthusiasms have been killed and many an incipient discovery blanketed through indifference or discouragement on the part of some educator."

THE APPLICATION OF RESEARCH TO INDUSTRY*

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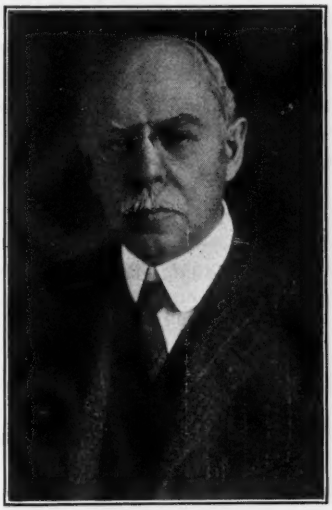
Man's Modification of His Environment
The Source of Man's Power—Knowledge
The Road to Knowledge—Research
Research the Basis of Material Civilization
Industrial Research a Necessity
Fruit of Earlier Researches
A Contemporary Example—Bakelite
Some Research Principles
Research and the Automobile
Present Status of Industrial Research
The Electrical Industries
Photography
The Personnel Problem
Rational Distribution of Research
Organization Essential
Making Research Pay
Pure and Applied Research



DR. ARTHUR D. LITTLE

Human beings generally, and young human beings in particular, take the world as they find it. It is fortunate that they do so for the habit is to most of us a necessary measure of self-protection. If one met every happening with full appreciation of its significance, the mind would be overwhelmed, and there would be little capacity left for action. We should be bewildered and obsessed by the complexity and marvel of the commonest occurrences, like the dropping of a stone, the changing of water to ice and snow and steam, or the leafing out of the trees in spring.

Man's Modification of His Environment

As it is with respect to the world of nature, so it is as regards the environment which man has created for himself. The generation which you represent has come into a world which develops and distributes energy on a stupendous scale; which is permeated by transportation systems, equipped with great factories and department stores, and lighted by the turning of an electric switch. It is a world in which people telegraph and telephone, ride in automobiles and go to the movies, send letters by air mail, and listen to the radio. Your generation very naturally and generally

* Opening lecture in the Students' Course at the Tenth Exposition of Chemical Industries, September 29, 1925. (Previously delivered under the auspices of the Cyrus Fogg Brackett Lectureship in Applied Engineering at Princeton University, on December 10, 1924.)

takes this world for granted just as you do the green of the grass or the hatching of a chicken from an egg.

But these things were not always in the world; most of them, in fact, have come into it within the period of my own recollection, and you have merely to go back to the yesterday of human history to come to a time when none of them were here. People did not always start the day with a bath tub and a safety razor, followed by grape fruit, packaged cereals, coffee, and the morning paper. They got along, in fact, as best they could, without most of the things that we regard as commonplace necessities. The family depended chiefly upon those things which could be produced by the labor of its own members. In the more remote districts, like the Highlands of Scotland, every man was his own weaver, fuller, tanner, and shoemaker, little more than a century ago.

The Source of Man's Power—Knowledge

We may well ask what has so greatly changed all this, so vastly extended man's power over nature and multiplied so many times the productive capacity of the individual. Many factors—social, political, economic—will immediately occur to you as having played a part in this development. You will recall the steam engine and the Industrial Revolution; the opening of new lands and new trade routes by explorers, the wide dissemination of knowledge made possible by printing, the coal and oil and vast supplies of other raw materials made available to industry, and you will give much weight to the influence of new social theories and new governmental systems. In the last analysis, however, you will find that this development has its basis in newly acquired knowledge and proceeds through the application of this knowledge to practical affairs. For want of knowledge the Hudson Bay Company trapped foxes over gold mines and our American Indians ranged and hunted over oil fields, coal beds, and vast deposits of iron ores. Watt was not the first before whom the lid of a tea-kettle had danced, but his recognition of the fact that the cause of its dancing was the energy of expanding steam resulted in his invention of the steam engine, in which that energy was utilized to move a piston. Thus he laid the corner stone of the Industrial Revolution, and the factory system of production by making power available in what were then large units. Because a magnetized needle was found to point to north and south, explorers pressed their ventures into unknown seas with new confidence, changing the course of trade and opening new lands to exploitation and development. Printing made its impression upon thought and culture and social theories only because it was preceded by knowledge of the art of paper making. Raw materials mean nothing to those who do not know how to win and use them. Social theories change and religious dogma bends under the shock of new discoveries. New means of transportation and

communication break through the barriers of political geography, and upon gunpowder are founded new governmental systems.

The Road to Knowledge—Research

But man has been in the world an unconscionably long time and, during all the long procession of centuries, he has been struggling to mold his environment to his liking. What has been the source of the new knowledge which, in this last brief period of one hundred and fifty years, has enabled him to remake the world? It has come because within that period he has for the first time systematically and intensively questioned nature; because he has developed and extended the research method and utilized its findings for the attainment of his ends. The influence of these findings has been profound in every department of life and thought—in many of them it has been revolutionary—but we are now, for the moment, concerned with the application of research to industry and with the reaction of industry to that application.

Extraordinary as many of the results of research have proved themselves to be, there is nothing mysterious about research itself. It is nothing more than the intelligent, purposive, organized study of the relation between cause and effect. As applied to natural phenomena its method is primarily the experimental one, which consists essentially in so establishing or noting the conditions under which an action is assumed to take place that the resulting sequence of events will supply the answer to a definite question. It is true that a high order of genius is often required to frame the question, arrange the conditions, and properly interpret the events which follow. A major research program is not unlike a military campaign. It may require the highest intelligence to define its objectives, organize the attack, and inspire the rank and file, but there remains ample opportunity for effective individual effort by the trained but less richly endowed subordinates.

Research the Basis of Material Civilization

We have attained our present standards of comfort and convenience only by raising the productive capacity of the individual worker. This has been accomplished in large measure through the factory system and the specialization of effort which that system permits, but the factory system itself involves the assemblage and coördination of a complex outfit of machines and processes, which, in turn, multiply the efficiency of the individual and which are themselves the product of invention, instigated and nourished by research.

With increasing populations and diminishing supplies of basic raw materials, the maintenance and improvement of the standard of living are obviously dependent upon our ability to continue to improve our industrial

methods. We may even go so far as to say that industrial progress supplies the basis for social and moral progress. It is hard to cultivate the amenities of life or the graces of the spirit in the absence of decent housing and of adequate food and clothing. It happens, however, that wealth must be produced before it can be divided, and the constantly rising demands of workers can only be met through the increased productivity of industrial operations. These demands, in the western nations at least, are already far beyond any possibilities of satisfaction that industry in its older and more primitive forms could afford. Not alone do the so-called working classes, but also those whose contact with industry is seemingly most remote, depend upon industrial progress for the maintenance of standards of living and the security of their environment. Its economic benefits permeate the community.

Industrial Research a Necessity

Industrial progress can, however, only be assured by the constant acquirement of new knowledge, which points the way to better control of operations, to new and better processes, new raw materials, new products, and to those new uses which extend the market. As Willis R. Whitney says, "We must first find facts, then find out how to use them."

In the past, industry has depended for new facts chiefly upon the more or less fortuitous findings of individuals, and these individuals had very commonly no direct relation to the particular industry affected by the facts. The complexity of modern industry and the intense competition between nations now require that any industry, to maintain its place, must consciously and unremittingly search out and apply those fundamental facts and principles with which its operations are concerned. Failure to do this spells ultimate disaster. Research moved the coal-tar industry from England to Germany, the production of indigo from India to Baden, and the making of photographic lenses from British towns to Jena.

Fruit of Earlier Researches

In a very real sense Research is the Mother of Industry and may even dispute with Necessity the parentage of Invention. Though invention may often seem to precede research, the essence of invention is the application of knowledge to new and presumably useful ends, and each advance in knowledge becomes a starting point and incentive for invention. A few examples will serve to indicate how strikingly this has proved true in the past and how deeply industry is already indebted to research. Nowhere is it more true than in research that "the gods send threads to webs begun."

The scientific work of Faraday in the Royal Institution laid the foundation for the immense superstructure of the electrical industries, which permeate our civilization with their activities and in which hundreds of

thousands of workers are now employed. In 1847 Schönbein effected the nitration of cellulose, the substance of the cotton fiber. Few events in the world's history have been so far-reaching in their consequences. From it have come guncotton, smokeless powder, blasting gelatine, celluloid, collodion, artificial and patent leathers, artificial silk, photographic films and moving pictures, lacquers, varnishes and automobile finishes, the impression blankets which alone make possible the operation of the modern high-speed, perfecting presses of our newspapers, triplex glass, and a host of special industrial applications.

The artificial silk, first produced by de Chardonnet from nitrocellulose, though profitable to manufacture, was expensive and otherwise open to objection. More research, by Cross and Bevan, led to the discovery of another cellulose compound, viscose, and today the production of viscose artificial silk far exceeds that of the natural product.

Scientists and economists alike were concerned not many years ago because of an anticipated shortage in the world's food supply. Growing crops require nitrogen, and the world's reserves of nitrogen in available forms were failing. It had happened, however, that Cavendish had reported, in 1785, the observation that nitric acid was produced by the passage of an electric spark through air. A hundred yearsl ater Bradley and Lovejoy, at Niagara Falls, by drawing air through an apparatus, by which 400,000 arcs were made and broken each minute, demonstrated the possibility of the commercial manufacture of nitrates from the air. Years later Birkeland and Eyde, in Norway, were producing thousands of tons of nitrates by passing air through furnaces in which it came in contact with enormous flaming and rotating arcs. An earlier visit by the German chemist, Haber, to the Bradley and Lovejoy plant turned his attention to the fixation of atmospheric nitrogen, and prolonged research led him to the development of the famous Haber process, in which ammonia is formed by exposing the appropriate mixture of nitrogen and hydrogen under high pressure to the action of a catalyst. Thus by research the world's supply of food has been assured, great industries have been established, and, incidentally, Germany was enabled to prolong the war for three years beyond the time when her supply of explosives would otherwise have been exhausted. Research has its destructive, as well as its constructive, side and in its sinister aspect can only be controlled by more research.

A Contemporary Example—Bakelite

Among recent industrial applications of research none is more notable than the development of the synthetic resin, Bakelite. We have heard much of artificial indigo and alizarine, but even these triumphs of organic synthesis have never reached the industrial importance attained by this new plastic within the last few years.

Bakelite is a so-called condensation product of phenol, or carbolic acid, and formaldehyde. In some forms it has the appearance of amber, and it is even easy to include the fly within its substance, but its mechanical properties are far superior to those of amber: it is infusible, untouched by any solvents, and possesses the high dielectric strength required for the insulation of modern electrical equipment. In an intermediate state it is plastic and takes the finest lines and configuration of the mold, but the polymerization induced by heat sets it in permanent form. It finds countless uses, ranging from those of ornament to electrical apparatus of almost every kind. From it are formed tubes and rods, noiseless gears, valves, ignition equipment for Liberty motors, and the propellers of airplanes.

It is interesting to consider how this marvelous transmutation of two such unlikely things as carbolic acid and the gas formaldehyde was brought about. As far back as 1872 Adolph Baeyer and his pupils had shown that it was possible to obtain condensation products of aldehydes and phenols, some of which had a resinous appearance. About 1891 formaldehyde was put upon the market, and Kleeberg and others attempted to extend the work of Baeyer. Some of them succeeded in producing resins, but these were either altogether intractable from the industrial standpoint or otherwise exhibited the usual properties of the natural resins, being soluble and fusible.

At the beginning of his researches Baekeland turned aside from these soluble and fusible resins, regarding them as inferior to such natural resins as shellac, and devoted his attention to the intractable products of the Kleeberg type, in the hope of finding a solvent which would permit their use in varnishes. Every solvent he could procure or prepare was tried without avail. Then he shifted his attack, reasoning that if nothing could be done with the substance when produced in the mass, he should attempt to carry out the reaction under conditions that would permit the product to be utilized. Efforts to impregnate wood with the raw materials and to effect the synthesis *in situ* within its pores proving abortive, Baekeland settled down to a long systematic investigation of the fundamental factors concerned in the reaction. His study of its several steps at last led him to the production of an intermediate body, resinous, brittle, soluble, and fusible, but possessing the remarkable property of changing at a temperature above its melting point to an entirely different body, incomparably harder and stronger than the intermediate and, unlike that, insoluble and infusible. He had arrived at Bakelite.

Some Research Principles

Concerning these researches Baekeland says: "When I undertook the intricate study of synthetic resins, which led to Bakelite, I did not rest

until I had mastered the details of the subject as far as my laboratory methods allowed me to do so. Then, since it is best to commit your blunders on a small scale and make your profits on a large scale, I immediately afterward installed a small working unit, where I could prepare the material in ton lots under various conditions, so that it could be tested right and left for practical purposes."

There is so much wisdom in the address which Dr. Baekeland gave on the occasion of the presentation to him of the Perkin Medal, that I venture to summarize some of his conclusions:

"Do not accept any chemical explanation in too simple terms. The very plainest chemical reactions are incomparably more complicated than our hasty generalizations in text-books lead us to believe."

"Do not scatter your attention on many subjects at the same time, and do not spend your enthusiasm on subjects unworthy of your best efforts. When you do undertake an investigation, concentrate on it your full attention and full enthusiasm until you have overcome all its main difficulties. Pick your business associates with more regard to exceptional personal qualifications and business experience than to the money they may subscribe, but remember that starting a chemical enterprise with insufficient capital is one of the most effective ways of ensuring failure and that every chemical enterprise should have at least one competent chemist on its board of directors."

M. C. Whitaker, another great master of industrial research, puts the matter in this way: he attributes his success to the care he has exercised "in the selection and training of his bosses" and says: "Many research projects are doomed to failure before they start because of the lack of interest or understanding on the part of the overhead. If research is to be a part of an organization at all, it is entitled to the benefits of coöperative support of every man in that organization from overhead to office boy. .....We always see to it that officers and directors understand what we are trying to do and how we are trying to do it. We discuss our projects and policies and program with them. We do not even deny them the privilege of sharing our disappointments and understanding our failures. We have received in return encouragement, confidence, support."

Research and the Automobile

The extent to which research now permeates industry is nowhere more strikingly illustrated than in the automobile. Its parts, of the alloy steels of Hatfield and others, are machined by the high-speed cutting tools developed by Taylor. All the refinements of metallography are utilized in the selection and heat treatment of metals and alloys. Flaws in castings are detected by X-ray apparatus. Strength and lightness are combined in the bodies of aluminum, which we owe to Hall and Héroult. Behind the

dynamo and storage battery and electric lights are years of research in many laboratories since Faraday moved a coil of wire across a magnetic field. The artificial leather tops, the celluloid panes in curtains, and the new Duco finishes are here today because Schönbein nitrated cellulose and because Parkes and many others have devoted lifetimes to the study of its properties. The rubber tire in itself has been the subject of prolonged research, and the introduction of organic accelerators in vulcanizing has permitted a three-fold increase in the output of the tire factories. The design of headlight lenses is governed by optical research, and tail lights give their warning because of red selenium glass. Because Ramsay, by the most refined research, discovered a new gas, neon, in the atmosphere, neon tubes are now in use for testing the efficiency of spark plugs. We have on file in our laboratory more than three thousand patents relating to the production of gasoline, and presumably behind each patent was research.

Present Status of Industrial Research

Whereas the laboratories of the great corporations are of the convergent type, in which the different lines of research, however diverse they may appear, tend to focus toward certain common objectives, a commercial consulting laboratory, like our own, is forced to work toward many objectives which may have no relation to each other, and the laboratory is consequently of the divergent type. There is thus some loss of continuity and mass effect, for which perhaps the compensation may be found in the versatility acquired by the organization through its contacts with many lines of industry. The special knowledge and experience gained in one of these may often be quickly and effectively utilized in other and wholly non-competitive industries.

The world unquestionably owes a great debt to German science, but the supremacy of German chemistry, of which we have heard so much, is a thing of the past. No American need go to Germany to study chemistry. He will be better taught at home, and American manufacturers now far outstrip the Germans in their appropriations for research. The American Telephone & Telegraph Company, through its subsidiary, the Western Electric Company, maintains, for example, a research staff of more than fifteen hundred chemists and engineers, engaged on development work alone, while in the field of applied chemistry the du Pont Company is preeminent for the size of its research appropriations and the range of its research activities. It is interesting and significant to recall in this connection that the founder of this great company was an assistant to Lavoisier, the father of chemistry. From the making of black powder its operations have extended into nearly every field of chemical endeavor, and always have its advances been founded upon research. It has employed at one time more than one thousand chemists, and as their labora-

tory findings have suggested new processes, these have been tested out upon the semi-commercial scale, as advocated in the extracts I have given you from Whitaker and Baekeland.

The Electrical Industries

In no industry perhaps are the results of research so obvious as in those which have to do with the applications of electricity to the needs of the community, and it is probably true that nowhere else has it been so clearly recognized that the basis of industrial progress is fundamental research. A laboratory experiment of Oersted disclosed a relationship between electricity and magnetism for he observed that an electric current deflected a compass needle. Later, another laboratory experiment, this time by Faraday, proved that a moving magnet can generate a current, for the needle of his galvanometer swung as he moved a magnet through a coil of wire connected with the instrument. Doubtless to the manufacturers and bankers of those times these seemed trivial occurrences, but they were more momentous to the interests of both than the Napoleonic Wars. On them are based our electrical industries with a book cost of $25,000,000,000, the great central-station plants for generating power, the transmission lines which convey the current at voltages as high as 220,000 for hundreds of miles, sub-dividing and distributing energy to factories, municipalities, and homes, and finally those quiet, efficient, electric motors which strip the factory of its belts and shafting.

The development of electric lighting began with Sir Humphrey Davy, who, in the laboratory of the Royal Institution, produced an arc between points of charcoal and raised a platinum wire to incandescence by the passage of an electric current. Years later Swan, in England, and Edison, in this country, after long experiment, brought out the carbon lamp. More research in the laboratories of the General Electric Company gave us the tungsten filament, and still more research produced the argon-filled lamp. Today a given amount of light is available to the manufacturer at 5 per cent of its cost in 1880.

Photography

Another field, in which we may with right and satisfaction claim preeminence for America, is that of photographic equipment and supplies. It is, again, a field in which that preëminence has been established through research of the fundamental sort. Time will not permit me to outline to you the varied research activities of even one of the companies in this field, but nowhere is fundamental research conducted more intensively or in better balance with applied research than by the scientific staff of the Eastman Kodak Company under the direction of Dr. Mees in its superbly equipped laboratory.

The Personnel Problem

Whatever the ultimate objectives of a research laboratory may be, its primary necessity is always that of finding and developing the exceptional man, who is hard to find simply because he is exceptional. Laboratory directors of the type of Mees and Whitney are first born and then made. In them exact scientific knowledge is vivified by a controlled imagination and directed by a sense of relative values. They have the optimism, contagious enthusiasm, and quick human sympathy which hold and inspire their staffs. When his objectives have been defined the director will endeavor to secure the maximum of hearty coöperation with the minimum of organization, since over-organization is certain to dampen the enthusiasm of the research worker, who is apt to be a temperamental person.

Industry in general must and properly should continue to depend upon the universities for that fundamental research, upon the results of which industrial research is commonly based. Nevertheless, as I have shown you, much fundamental research of the highest type is now conducted in the laboratories of our larger corporations. It is, moreover, probably true that the quality and effectiveness of industrial research rises in proportion to the depth to which it strikes its roots into the subsoil of fundamental fact and principle. Mere wildcatting for processes is not research and seldom brings in a paying well.

Rational Distribution of Research

In considering the relation of the universities to research Steinmetz said, "Researches requiring little in facilities, but a large amount of time and attention of research men, are especially adapted to educational laboratories, while investigations requiring large amounts of material or of power, rather than time of the investigators, are specifically adapted to the industry, and often beyond the facilities of the educational institution."

Much research of the utmost value to industry is conducted in the laboratories of the governmental bureaus and departments. A large proportion of this is of a sort that could hardly be conducted effectively except under governmental auspices, either because of its cost, or the great length of time required for the assembly of data and interpretation of results, or because of the many agencies which must be brought into cooperation. Examples of such types of research are found in the work of the Bureau of Mines, the Geophysical Laboratory, the various bureaus of the Department of Agriculture, and the Geological and Coast Surveys. Since research, to be effective, must have exact units of measurement the work of the Bureau of Standards in defining such units and establishing the accuracy of measuring instruments and methods of testing is of the first importance as an aid to industrial research.

Organization Essential

Executives, who expect research results from the rubbing of a lamp, or its modern equivalent, the signing of a check, are doomed to disappointment. A successful laboratory for industrial research is a plant of slow growth. There is no rule or method which will ensure the selection, in the first instance, of a staff of the conspicuous abilities and traits of character requisite for effective coöperation in this difficult field. Only repeated trial and elimination will disclose the individuals who can be welded into a smoothly working organization. Once that stage is reached every care should be taken and every inducement offered to reduce the turnover of personnel to the lowest possible limit. Success in industrial research cannot, moreover, be expected until the members of the organization have collectively acquired intimate and detailed knowledge of the material, methods, objectives, and inhibitions of the particular industry concerned. As each specific problem is presented they must familiarize themselves with the great mass of technical, patent, and scientific literature, which bears upon it, and thus gradually accumulate in special data files and laboratory records the specialized information which increases the efficiency with which each succeeding problem may be attacked. In view of this and the fact that the first step in any major research undertaking is a careful review of the literature, it is obviously necessary that the budget of any research organization make generous provision for library upkeep and personnel.

It is highly desirable for a corporation to centralize its research facilities and staff for the efficiency with which research can be conducted increases far more rapidly than the number of workers, provided these have been selected with due regard to specialization in the various departments of the sciences with which the work of the laboratory is concerned. It is also stimulating and helpful from many points of view to have associated with the staff and available for consultation, suggestion, and criticism a few outside specialists on the retainer basis.

Making Research Pay

Since, to justify its existence, the dollar sign must always ultimately appear in the final equations of the industrial research laboratory it is necessary that somewhere within the organization provision be made for thinking in terms of tons, digesters, and tank cars, as well as in those of grams, test tubes, and 8-ounce bottles. Otherwise the mortality of infant processes is likely to be high. There is far too little appreciation of the difficulties of the rocky road that leads from the laboratory to the plant. They are admirably set out in the Perkin Medal address of M. C. Whitaker.[1]

[1] *Ind. and Eng. Chem.*, **15**, 200 (1923).

When, therefore, the laboratory findings have well established the conditions governing the course of the reactions, when all that the prior art has to offer has been reviewed in its relations to the project, it remains to develop ways and means for profitably carrying out the process on the commercial scale and determining the place of the product in the market. It is our own practice to divide this development into several stages, their number being determined by the difficulties anticipated or encountered. First comes the large laboratory stage, the range of which has been greatly extended by the introduction of pyrex glass. Here yields are established, the balance between pieces of equipment roughly indicated, their general type tentatively fixed, and moderate quantities of product made for testing purposes. With the experience thus gained larger experimental equipment is designed, set up, and operated. Materials of construction are tried out, methods of heat transfer studied, systems of control developed, and the type and balance of equipment settled as definitely as may be. Then, when all is going well, we proceed with the design of a unit of semi-works size for the training of an operating staff, the demonstration of output and costs, the ironing out of operating difficulties, and the production of material in sufficient quantity for commercial trials. Not until these matters are settled to our satisfaction do we feel justified in undertaking the responsibilities involved in plant construction.

Pure and Applied Research

Industrial research differs from pure research only in its motive and its immediate objective. It employs the same methods, demands the same skill and the same high intelligence and training. It is, however, and not wholly to its disadvantage, always under a pressure of the time factor, from which the worker in pure science is measurably free, and it must, if it is to be regarded as successful, pay its own way and yield a profit. That it does both, when properly organized and directed, is demonstrated by the generous and growing appropriations for research made by our larger corporations. With the more modest resources of our own laboratory we have been able to contribute to industrial progress processes for cellulose acetate, artificial silk, airplane dopes, chrome-tanned leather, chlorate of potash, the separation of zinc from complex ores, new types of paper and paper products, and many improvements in industrial technique. We now confidently believe that we are about to effect a radical readjustment and enhancement of the values derivable from petroleum.

SYMPOSIUM: WHAT ARE OUR OBJECTIVES IN TEACHING CHEMISTRY?*

IN OPENING this discussion the speaker would like to call to mind some points in regard to the situation in which we as teachers find ourselves.

There is a very general belief among educators that in the field of science less efficient teaching is being done generally than in the fields of mathematics and languages, either ancient or modern. That is, compared with accomplishments reasonably to be expected in these contrasted fields, the actual accomplishment in science is proportionately lower than in the others. This is frequently explained by friendly critics as due to the fact that in the newer subjects the work is not as well organized as in the older fields, where centuries of experimentation by the trial and error method have resulted in the general adoption of more effective procedures.

The fact that a belief is general does not, of course, increase its probability of being true, and we as scientists would be quick to call for the evidence justifying this opinion. Among ourselves, however, we might devote a little time to discussing the question whether such evidence as we have indicates that the teaching of chemistry on the whole is approximating reasonable expectations or falling far below this level.

Concerning college teaching, statistical evidence is almost completely lacking, a fact which for some time yet will allow college teachers to maintain the self-esteem which they as a class may possess.

With reference to ~~the much more extensive field of~~ high-school instruction, evidence has been accumulating within recent years which furnishes little reason for contentment concerning the situation. The studies made by Powers and others[1] as to the effectiveness of high-school teaching in chemistry support, with evidence, a belief which for years some have felt must be true. That is, assuming that high-school chemistry teachers are honestly working with their students during the hours scheduled for chemistry instruction (and of this the speaker has no doubt), there must be considerable misdirected effort to account for the general meagerness of results as shown by college freshmen.

The speaker would pause here to remark, first, that he has just stated what he believes to be facts which can be scientifically demonstrated. These supposed facts are unpleasant to many people in different walks of life. The speaker is not charging the responsibility for these facts wholly or mainly to the teachers of high-school chemistry.

Secondly, that though they place great faith in the value of methods, departments of education too often fail to emphasize the necessity of

* Discussion at the Los Angeles Meeting of the A. C. S., August 4, 1925.

[1] Powers, S. R., "A Diagnostic Study of the Subject-Matter of High-School Chemistry," *Teachers' College Contributions to Education*, No. 149 (1924). Partially reprinted in THIS JOURNAL, **2**, 174–80 (1925).

sufficient knowledge of the subject-matter handled. This is of the utmost importance if the application of sound methods to unfamiliar material is not to lead to results that are so lop-sided, because of distorted perspective, as to be of little value. It has been opined that the futility coefficients of some of the studies in education and psychology approximate closely to one hundred per cent for this reason. Nevertheless, the speaker reads with interest of any attempt to get a more scientific method of evaluating the results of teaching, for he is convinced that there is much lost motion in the educational process beginning with the kindergarten and ending possibly with the Ph.D. degree.

It is easy to find fault with the character of Power's tests, and the speaker was strongly inclined to do so on first reading. All things considered, however, Powers is not to blame for his results. He has furnished scientific evidence in support of opinions previously held and has demonstrated the existence of a situation that needs correction. This is a service rendered to high-school chemistry teaching.

Powers based his tests on examinations given in chemistry, and they do not differ in any significant way from the general run of chemistry tests. He gave these tests to hundreds of high-school students near the end of their year's study of chemistry and found approximately two-thirds of the answers correct. These facts indicate that the material contained in his tests may be considered as a fair sample of the material actually given in chemistry classes, at least in the schools tested.

These same tests were given to college freshmen who had chosen to continue chemistry in college. Students who go to college constitute a group specially selected from those who graduate from high school. The students who elect chemistry form another special group selected from those who enter college. Both of these factors should tend to increase the proportion of correct answers received. Yet there is a distinct falling off as 3, 15, 27 or more months elapse between the completion of the high-school chemistry course and the time of taking the test.

On the basis of the results obtained from individual questions, as well as the combined result from all tests, Powers says, "Each of the tests of subject-matter points to the conclusion that a large proportion of the content of high-school chemistry is of little or no value for many who study it. Certainly there are large numbers who effect no mastery of the subject-matter. It appears that there are many schools in which nearly none of the students obtain any mastery of the subject-matter which is presented to them. The second test shows that such mastery as is obtained is rapidly lost by forgetting when the student has left school." Powers then quotes from an address of the president of Brown University given in 1854 to the effect that at that time the result of instruction in high-school chemistry was essentially that shown by Power's study to be true now. In this re-

spect then, there seems to have been little change in three-quarters of a century.

The objection has been raised that "Powers formed his tests out of exactly that kind of material that anyone would forget most rapidly, that is, from material chiefly informational in character. Everyone knows that informational stuff is quickly forgotten. Probably tests of a similar character given in any other department of education would show just as poor results."

The speaker believes these objections to be well taken in general. An analysis of Power's results shows that the highest percentage of correct answers was obtained on the third division of his questions where the necessary information—the valences of the elements—was given. The small amount of chemical training necessary to write formulas for compounds when the valences of the elements are known is apparently very generally mastered by the students.

But, admitting the truth of these criticisms, are these objections of significance? Powers has studied instruction in chemistry as it is, not as it might or should be. Is there a larger proportion of informational material in his tests than there is in the instruction as actually given? Evidence indicates that there is not.

Text-books are very largely informational in character. They must be so in order to furnish diversified material for illustrative purposes. Unless "the whole book is learned," they do not furnish a satisfactory basis for estimating the proportion of information given in the class-room. Test papers are a more reliable guide as to the points which are considered by teachers to be of importance. The College Entrance Examinations Board tests in chemistry have been reported at various times to run from 75–90% of informational material as judged by different appraisers. In the revised report of "A Standard Minimum High-School Course in Chemistry"[2] there are over four pages of "Topics for a Standard Minimum High-School Course in Chemistry." Opinions as to the proportion of informational material contained in these four pages rendered by chemistry teachers (who have read this report with this question in mind) vary from 75–85%.

Power's tests do not contain more than 75–90% of informational material. From all available evidence then, it must be concluded that his tests are a fair sample of the material covered in the class-room.

All admit that a certain amount of information has to be learned and used by everyone. The more intelligent the individual the larger is the amount of information mastered. But the information which is mastered and used is not generally learned from books, but is picked up piece by piece from personal contacts which cause psychological reactions to take

[2] THIS JOURNAL, 1, 87–99 (1924).

place, fixing the information in the mind. When studied from books, a list of the kings of Egypt, England, or Patagonia, the books of the Bible, the major prophets, the atomic weights of the elements, the forms in which the elements occur in nature, and the methods of manufacturing a host of chemical compounds—all these are probably of nearly equal value as a part of a general education. Practically all will be forgotten very soon indeed, and their educational value thus established. The same length of time spent in learning good poetry would probably make a higher educational return.

If it is thought worthwhile to seek to place the responsibility for the situation found to exist in the teaching of high-school chemistry, we may ask—Who trains the teachers? Who writes the text-books used? Who compiled "The Standard Minimum High-School Course in Chemistry?" Who makes up the College Entrance Examinations Board tests? The answers to all of these questions are much the same. College teachers cannot escape a large portion of the responsibility for the content of high-school courses in chemistry. This strongly suggests the inference that many college courses are as largely informational in character as are the high-school courses.

Now if "everyone knows that informational stuff is quickly forgotten," and if its infinitesimal educational value is established by this fact, what justification can be offered for giving a large proportion of informational matter? We ridiculed the history teachers of a generation ago because of the lists of kings and dates of battles required if one would then be educated; and, smarting under the stings of our jibes, they developed the scientific method of teaching history, making it a study of cause and effect. Shall we say that scientific information is of such essential value that every educated individual must be taught a great amount of it? The teachers of the classics maintained this position for centuries, yet today their standard is followed by a mere handful of students. John Dewey, one of the greatest educators the world has produced, has repeatedly stated that science offers nothing so valuable to mankind as a knowledge and appreciation of the scientific method. In one of the most significant books that have been published in recent years, James Harvey Robinson[3] maintains that rational thinking (or the scientific method) has contributed more to the advancement of mankind than all other human efforts put together, and that nothing is now so important in education as a knowledge of its past accomplishments and future possibilities. Yet in the report of "A Standard Minimum High-School Course in Chemistry" there is no mention of the scientific method. Apparently, "a prophet is not without honor save in his own country."

If in our classes we are not continuously to emphasize and show the use

[3] "Mind in the Making."

of the scientific method—the method of straight thinking regardless of consequences to previously held beliefs or prejudices, the method of inferential reasoning—what are we to teach? Valuable scientific information? Are we to teach our students a bag full of tricks, possibly but not probably convertible into cash on sight? How to make sulfuric acid and white lead, washing soda, and Paris Green? Will this knowledge make a person educated to a greater extent than knowing whether the Latin prepositions, *ad*, *ante*, *con*, *de*, *in*, *inter*, *ob*, *post*, *prae*, *pro*, *sub*, and *super*, are followed by the accusative or ablative? The evidence indicates clearly that many are teaching information largely, but far more clearly every test demonstrates that this information is soon forgotten and is of little functional value. Shall it continue to be said that chemists spend much of their class-room time and energy in trying to do the impossible—to get students to master informational stuff—while at the same time they fail to emphasize sufficiently the most valuable contribution to education—the scientific method?

What are we trying to do in teaching chemistry? Shall we endeavor to make of the minds of our students depositories of information in which the moth of forgetfulness and the rust of disuse will corrupt the facts? Shall we not teach them rather to know books and use libraries which will in time of need furnish them with exact information in a thousand-fold greater abundance than any one mind can comprehend? Shall we not strive to develop mental laboratories and teach the use of their equipment so that every last one of our students may realize the value of evidence and to some extent learn how to obtain it?

Some one has said that "Education is learning to use the tools which the race has found indispensable." Rational thinking is the most productive tool ever invented, though it has never become popular as jazz or vanity boxes have. Than in the field of chemistry no better opportunity is offered for teaching how to think—how to solve problems by using one's brains.

When you have taught a lad to swim, what per cent is lost in 3, 15, or 27 months—or years? When one has learned to ride a bicycle or to skate, does he ever forget how? When you have taught these, you have developed powers which the one taught did not realize he possessed. You have given him new tools. With the field of chemistry furnishing the illustrative material, shall we not endeavor to teach our students how to keep their heads above water, how to maintain their balance, how to make progress? These things they will never forget whether they be in the realm of the mental or the physical.

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IN TRYING to determine why we are teaching chemistry to high-school students and college freshmen we should not forget that our one course is all the formal chemistry the vast majority of them will ever get. With comparatively few exceptions they will not specialize in chemistry. When they leave school they will go into other lines of work; into the professions, into business, into the industries, into politics. They will be leading men and women in the community in spite of the opinion we may hold and sometimes express as to their natural abilities. We judge them without sufficient acquaintance with those others who never reach the high school or college, by comparison with whom we should have a much better opinion of our own students. We are therefore dealing with young people who in the future will be men and women of influence, who will be leaders of thought and action in the community. What kind of training should we like such ones to have?

For our leaders in society we should *like* to have high-minded men and women who have a broad outlook upon life. We should like men and women who can think, who have judgment, who can work and who have initiative and resourcefulness in attacking their problems. We should like men and women who have the courage of their convictions, men and women of vision, perspective, and broad human sympathies. This is partly a job for Mother Nature herself, but it is not altogether hers, else we should have no need for schools of any sort. This is what President Hopkins of Dartmouth has in mind when he says, "The purpose of a college education is to give a man complete command of his faculties and the ability to think clearly and independently." It is for the educator to give the raw material he gets from nature every opportunity to develop into the kind of men and women the community needs. I believe there are few if any subjects better adapted for this purpose than is that of chemistry. The beginner goes exploring into what is to him an entirely new field where he should be able to use his imagination, his reason, his judgment—in fact all his faculties to his heart's content. Do we always give him the chance?

Another qualification we should like for our leading citizens to have is open-mindedness. This is the great need of the present. It is almost too much to hope that our political, financial, social, and industrial problems may sometime be solved by open-minded men and women. Yet we do entertain such a hope. James Harvey Robinson in his book on "Humanizing of Knowledge" has well said, "Of all human ambitions an open mind eagerly expectant of new discoveries and ready to remold convictions in the light of added knowledge and dispelled ignorance and misapprehension is the noblest, the rarest, and the most difficult to achieve."

There is probably no better place for a student to begin the *scientific method* than in the subject of chemistry. This is one of the more exact of

the sciences where experiments may be tried and definite results obtained. In chemistry it is easy to see why certain hypotheses were proposed to explain certain phenomena and that failure to take into account all the facts inevitably leads to false conclusions. The student will see that to make real progress he must keep his mind open. I cannot refrain from adding, however, that if chemistry is a good place to begin the use of the scientific method, it is not necessary to confine its use to this science. One of my colleagues once said, "We chemists are *always* open-minded *except* when we go outside of our specialty. We are willing to take account of all the facts in our own problems, but when it comes to questions on politics or education or the labor problem our minds are not always open."

A third thing that we should like for our leaders to have is a full realization of the role that chemistry plays in life and sufficient grasp of the *most* fundamental things to enable them to appreciate its applications and possibilities when chemistry is involved. That the public is grossly ignorant of chemistry and the value of chemical knowledge in the solution of public problems needs no argument before a body of this kind. This ignorance exists among educated people, among men of affairs and among most of those who at the present time comprise our leaders in society and mold public opinion. It is important, therefore, that we take steps to dispel this ignorance. We should see to it that it does not exist among our future leaders, who are now taking their one course in chemistry. It is urgent that we plan *this* course with these future leading citizens definitely in mind. They are more to be considered than the ones who are to specialize in chemistry. Any false notions or any deficiencies in the preparation of the specialist there will be ample opportunity to correct, but the impression the one-course man carries away is likely to be retained for life. Will he go with the feeling even though unexpressed "I certainly did a lot of cramming in that course and I'm glad it's over. What does it all mean, anyhow?" Or can he be made to feel "An interesting subject. It gives me a clue to the explanation of a lot of things. I'd like to inquire further into some of them."

It is a matter of the utmost importance that this course be so planned and the material for it be so selected as to enable the student to get understanding, as to arouse his interest and in the end to make him feel that he has at least a general idea of what it all means.

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IT IS indeed encouraging that through the medium of our society we teachers of chemistry come from the college, the university, the private school, and the high school and are permitted to meet on the common

ground of interest for the discussion of our problems. It is even hoped that among our number here today may be found representatives from the industrial and research field for, if we but knew it, this great business of chemical education is a problem that touches us all in one way or another. When the teacher of high-school chemistry sits down with the university teacher and the common problems of both are discussed much good comes and many of the misunderstandings of the past will disappear. By the substitution of meeting and discussion for the old practice of sitting each in his laboratory and condemning the ideas and practices of the other we fulfill at least the first of the qualifications of progressive teachers.

In high-school teaching at least we have, I feel, passed beyond the stage of formulating aims and objectives. These have been set up for our guidance and they should at all times be a part of our consciousness. But we have come squarely to the serious task of developing effective methods of teaching in order that our objectives may be attained most successfully. The progressive teacher is never satisfied with the results of his work but is constantly experimenting with this new scheme or that in the attempt to improve his teaching technique. It is inconceivable that this might work any permanent hardship on the pupils of such a teacher. Dr. Edwin Slosson has said, "Science teachers in the secondary schools occupy a strategic position for influencing the thought of the nation. They give all the instruction that most of the people ever get and they have the first chance at those who go on to the university. Upon such science teachers, therefore, rests the responsibility of presenting science in the beginning in its integral and humanistic aspects. I venture to say that such a presentation gives the best foundation for future specialization and abstraction." Thus we must agree that our responsibility is fixed and great. What are we to do with it?

Such meetings as this will accomplish the greatest good if they serve as a true clearing house of ideas, if we may listen to accounts of various experiments in the teaching of chemistry, and if there be free and honest discussion of such experiments, their implications, and conclusions.

Powers, in a rather careful study (THIS JOURNAL, **2**, 174–180 (March, 1925)), has shown that the specific information about the subject-matter of high-school chemistry is rapidly forgotten and he concludes that "the absence of functional value of the subject-matter which is forgotten is established by the fact that it is forgotten." "We do not forget how to do the things we are doing nor do we forget the facts we are using. In the absence of functional value there remains the possibility of a training value. Training in methods of memorizing, acquiring skill, solving problems, and in maintaining proper attitudes is an important task in education as well as the mere accumulation of information and skill." If the facts of chemistry

are rapidly forgotten and the only hold-over be the method of science together with possibly some habits of caution, accuracy, and thoroughness, and an added quality of appreciation, should not this cause us to check over carefully our courses of study to select the most appropriate subject-matter and the most effective teaching technique for accomplishing such training? Gates states ("Psychology for Students of Education," pp. 37–72): "For two reasons we may expect a greater transfer to the activities of daily life from subject-matter which is itself directly useful in situations commonly encountered outside of school. First, in order to deal with the situation in life we need to know the facts involved. Second, the transfer of methods of attack, poise, devices of learning, habits or ideals of caution, accuracy, thoroughness, or initiative to the situations in life will be great to the degree that the subject-matter of the class-room is identical with that used in situations which life offers."

Dewey ("Democracy and Education") states: "There is a strong temptation to assume that presenting subject-matter in its perfected form provides a royal road to learning. What more natural than to suppose that the immature can be saved time and energy, and be protected from needless error by commencing where competent inquirers have left off? Pupils begin their study of science with texts in which the subject is organized into topics according to the order of the specialist. The pupils learn 'science' instead of learning the scientific way of treating familiar material of ordinary experience. The method of the advanced student dominates college teaching; the approach of the college is transferred into the high school, and so on down the line, with such omissions as may make the subject easier. The problem of an educational use of science is then to create an intelligence pregnant with belief in the possibility of the direction of human affairs by itself. The method of science engrained through education in habit means emancipation from rule of thumb and from routine generated by rule of thumb procedure."

Powers has suggested the need of curriculum studies in science looking to larger divisions than the units of physics and chemistry and I believe that we are coming more and more, in the secondary school at least, to an organization of sciences with each succeeding course related to and built on the preceding one. The first unit of such an organization will include science from many fields. Naturally in such a plan the dividing lines between the individual sciences will disappear and the borders to an extent at least will merge. In determining the content and method of such science courses we must first conduct a careful study into what people need to know about science, states Powers. Once we obtain this fundamental information we may then intelligently organize into teaching units those materials which will give to students the kinds of experiences, knowledge, habits, and appreciations which will be of largest value in after life. At a

recent conference on the position of the sciences in education held in Berkeley under the auspices of the Amer. Assn. for the Adv. of Science such a recommendation was incorporated in the official report to the central body of the association.

We need, it seems to me, first a revaluation and reorganization of the subject-matter of elementary chemistry, and second, a careful revision of our technique of teaching. The demand for reorganization of our high-school chemistry course is imperative for at least two reasons. First, the wide introduction into our schools of courses in general science and biology requires of us a recognition of the pupil's experience in these sciences during his early years in the high school. Second, the enlarged scope of the field and science of chemistry necessitates the introduction of new material into the course. The material resulting from recent discoveries in the field of atomic structure, since it offers a fundamentally different idea of chemical phenomena, is so important as to require a prominent place.

If we could have from the colleges and universities a revision of the minimum essentials demanded of high-school chemistry so that uniformity might prevail we could then proceed more intelligently with this task. It is perfectly feasible, I believe, to prepare our pupils for advanced work in chemistry and at the same time to secure those values which are so essentially a part of the student's preparation for life itself.

In the remaining time I shall with your indulgence, outline briefly some essentials in the technique of teaching which have been developed in our science department at University High School, Oakland, during the last eight years. In way of explanation perhaps I should state that University High School is a unique institution, operated, and financed under a joint agreement between the University of California and the Board of Education of the city of Oakland. For the University it is a training school for candidates for the high-school teachers' credential and a field of observation for the School of Education. For Oakland it is one of six high schools engaged in the education of the city's children. During the year just passed some 260 graduate students from the University received training at the school and of this number some 45 came under the supervision of the members of our science department staff.

The Class Discussion

The class discussion serves as a center from which the activities of the class radiate, and a clearing house toward which these activities eventually converge. Inspection of the chemistry teaching carried on in our high schools leads one to the conclusion that little real relationship usually exists between the work of the laboratory and that of the class discussion or recitation. The latter, most frequently, is a "hearing of lessons" over a certain portion of text-book subject-matter, while the former comprises a

certain discrete unit or task outlined for the pupil in a laboratory manual. Little articulation is found. One remedy for this situation may be brought about by organizing the class discussion, special reports, demonstrations, and laboratory work around definite problems. A few carefully prepared, well-directed questions by the teacher will usually start a discussion in which many of the facts and ideas may be supplied by the pupils themselves. It will not be possible, obviously, or perhaps even advisable, to organize an entire chemistry course around problems but the wide use of the problem as a means of unification surely is advisable.

Text-Book and Reference Material

No attempt is made to confine the pupil to the use of a single text-book during the course, although a copy of a standard high-school text in elementary chemistry is furnished him by the state. The plan of having on hand in the chemistry room several sets of reference books for use by the class as a whole has proved exceedingly valuable. Practically all assignments of reading are made in the form of sets of study questions. A page by page assignment is considered little short of rank heresy.

The Teaching Test

Too frequently is the conclusion borne in upon us that the complexities of our modern system of education do not permit us to teach thoroughly even though we would. Morrison (*School Review*, **29**, 3 (March, 1921)) has made the timely suggestion that we need first of all to get back to some solid ground, from which to make a fresh start in our thinking if not in our practice. He says, "We can find the solid ground in the concept of mastery, in the old notion that what is worth doing at all is worth doing well. You either understand a principle or you do not; there is no such thing as a 70 per cent understanding. You can either do a thing or you cannot, there is no half doing it nor three-quarters doing it. You may understand more of a subject than another, you may do a thing better than another, but understand or do you must. Nor does mastery in school work involve any serious difficulties. It does involve a new conception of teaching and a new orientation in administration. It involves ceasing to measure a pupil by his average mark and measuring him by the excess quality of his achievement. It involves ceasing to evaluate our success by averages or medians of class achievement and beginning to measure ourselves, as other scientific workers do, by the percentage of failures."

After organizing our chemistry course into large blocks or units, each of them capable of mastery in terms of understanding or capacities of appreciation, we next turn to the task of developing a technique whereby a class may be led to mastery. In the formula of Morrison, "Teach, test, and teach again if necessary," we find a hopeful scheme for attaining our objectives.

As he has so ably pointed out the teaching test is of value chiefly as evidential material; as an absolute criterion its value is almost nil. The moment it becomes a means of measuring the pupil its evidential character is lost and it becomes worthless. The most difficult part of the plan is for the teacher to orient himself anew in his attitude toward the results of his testing.

The newer types of test such as completion, true-false, matching, and selection are, for the most part, used in this connection. At intervals during the progress of work on one of the large units of the course, tests of the types mentioned are given. These tests usually can be completed in 15 to 20 minutes and are so designed as to permit of simple, mechanical grading by the pupils themselves. Examination of the papers reveals at once the topics which need presenting again as well as the individuals who require speical attention. For the small group of exceptional pupils who rather quickly attain mastery of the unit, supplemental work in the way of experimental problems, reading, special reports, and demonstrations is assigned or chosen. Special attention is given those individuals whom the test has shown to be deficient in mastery of certain parts of the material. A more comprehensive test is given at the close of work on the large unit.

The Laboratory

Work in the laboratory is carried on through the medium of problems which arise during class discussions. It is important that the pupil feel the worthwhileness of investigating a given problem else his whole-hearted effort is not exerted. The problem, which usually arises from some situation developed during the class discussion, is first given a definite formulation by the class. This forms the purpose of the laboratory experiment. Time is then given the pupils to outline a method of attack, following which suggested methods are presented and discussed, with the eventual selection by the class of the most feasible. The selected method (sometimes there may be several modifications) is outlined clearly on the black-board and the pupils enter the notes under "procedure" in their laboratory note-books. At all times the instructor places a decided premium upon original thinking and initiative. If individuals express a desire to try out different methods than the one selected by the class group they are always encouraged to do so.

All of our laboratory work is carried on in this way without the aid of a laboratory manual and our results with the scheme in chemistry classes have been so successful that it is now used in all of the science classes of the school. The plan is in no way an experiment as it has been developed and successfully used during a period of seven years. To the teacher who has used the laboratory manual in chemistry teaching such a plan as ours comes as a distinct shock. The technique is difficult to acquire and demands the

best thought and effort on the part of the teacher. The results, however, are sufficiently convincing to reward one for the additional effort expended.

It is neither essential nor advisable that all pupils carry on experimental work in the same manner at the same time. Individuality and originality are constantly encouraged. This does not mean that standards of proper laboratory technique are in any sense to be disregarded by the teacher; on the other hand, the pupil who has made a real contribution toward the formulation of a workable scheme for solving a problem in chemistry will naturally take pride in conducting his experimental work with the best technique of which he is capable.

Obviously, it is not always possible for pupils to formulate all of the details of a given procedure and in such cases definite suggestions may be supplied by the teacher or reference made to some authority. No appeal to teacher or book is ever made, however, until the resources of the class group are exhausted.

The Note-Book

Students are required to purchase a blank note-book with numbered pages and at the beginning of the term considerable time is given to instruction in proper means of recording observations, tabulating results, and stating conclusions. The purpose of the experiment is stated in the pupil's own words, the procedure is briefly outlined in steps, in the laboratory he records results and conclusions, and finally he prepares a summary of what he has learned. The note-books are inspected at frequent intervals by the teacher who indicates corrections, additions, and modifications that are necessary. Needed changes are made by the pupil and his book is again inspected. This procedure is carried on during the first month of the term to acquaint the pupil with the best means of keeping a record of his laboratory experimentation. At the close of each experiment, either on the same day or at the next meeting of the class a quiz is given on the laboratory work just completed. This consists of very brief questions (previously weighted by the teacher) which are aimed to measure the pupil's comprehension of the purpose of the experiment, the accuracy of his observations, his ability to associate facts, interpret results, and draw conclusions from these observed facts. The quiz commonly requires but 10 or 15 minutes to write after which papers are changed. The teacher then goes over the questions carefully giving the correct answers, the pupils scoring the papers. Brief discussion of any obscure points is carried on during the scoring of papers. Papers are then returned to their owners and after a short interval are collected by the teacher. The papers are arranged in serial order according to scores and the median paper found. Grades are then distributed and recorded.

After the first month the note-books are no longer inspected by the

teacher who bases his estimate of the pupil's laboratory work largely upon his record in the laboratory examinations. Our experience has shown that pupils continue to use their note-books in practically 100% of cases even though they are never called for by the instructor. The plan just described has proved so successful during the school year just past that we plan to make it a regular part of our teaching technique in chemistry. It has the following decided advantages:

(1) The note-book is kept by the pupil for his *personal use* only. Under the traditional scheme the note-book was written up for the teacher and so far as my experience and observation go it has never fulfilled the purpose for which we agree it was designed.

(2) By knowing that he stands or falls on his record in the laboratory examination the pupil sees to it that he understands the purpose of the experiment and that he has correct notes as to the proper procedure.

(3) He is on the alert to make correct observations, to interpret his results properly and to draw right conclusions.

(4) The teacher is spared many hours which are consumed in inspecting and grading note-books. He thus gains time which may be devoted to the more profitable employment of enriching his chemistry course with material that will be both of interest and value to the learner, and for perfecting his teaching technique.

The foregoing rather brief, and I fear inadequate, description may serve to acquaint you in a general way at least with some of the devices which we have developed in our chemistry classes during the past few years. As departures from the traditional method in high-school chemistry teaching they have proved interesting and stimulating to us. Experimentation has always made us want to experiment further. We have been repaid many times over in the growth of interest on the part of our pupils, in the steady increase in enrolment in our chemistry classes, and in the ever-widening group of our graduates that take up advanced work in the sciences in institutions of higher learning.

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OUR PRIMARY object in teaching chemistry would seem to be the advancement of civilization and man's well being. To this end we may, through popular lectures, acquaint the layman with the growing importance of our science, while we are preparing the sons and daughters of America for teaching; laboratory and plant control; the practice of pharmacy, dentistry, medicine, the engineering, mining, and other professions; and finally for the real field of accomplishment, research. "What we teach"

depends on the individual's goal. Curricula constitute an everlasting topic of discussion. "How we teach" would seem to be a topic that might well engage our attention during a part of this session. Here are a few thoughts for your consideration.

It would seem desirable to have small laboratories so that students in undergraduate courses might be grouped and allowed to progress according to their ability. With this in mind a laboratory should hardly accommodate more than twenty-four students. The student is at present generally scheduled for a number of lectures and recitations each week and can devote but a limited amount of time to laboratory practice. Under the new plan, only laboratory practice would be scheduled and the student could from time to time confer with the instructor in charge of his laboratory. A small library of suitable books near the laboratory should facilitate reading and a search of the literature, and the student would be encouraged to seek information for himself, thus developing self-reliance. The policy of having one task satisfactorily completed before another is begun would enable us to send thoroughly reliable men into public and industrial service. Grades based on the quality of a man's work would be abolished. He would receive credit for the quantity satisfactorily completed and could be sent into the world of affairs a thoroughly reliable worker, slow, average, rapid, alert, as the position might require.

Having a number of small laboratories for undergraduate courses, in which there is a heavy enrolment, would enable the instructor to sectionize students according to their ability. At present students have lectures, recitations, and laboratory practice, and it is possible to use a laboratory for a good many sections each week. Fewer can be scheduled by confining work entirely to the laboratory, but the advantages accruing to the students would justify such a step.

It is more criminal to waste human energy than other natural resources. By sectionizing on the basis of ability, and giving the slow student an opportunity to go his pace, perhaps gradually developing him into a more rapid worker, we can materially reduce the size of the educational "scrap pile." The superior student, who now has his ambition curbed in a class with average or inferior students, would be encouraged and inspired to go on. It seems unfair to flunk a man because he is too slow and to hold a good man back. These are the faults of our present educational system which are in dire need of correction.

It would also seem desirable to have a student carry fewer subjects, and apply himself more intensively to those scheduled. Our experience during the summer, when a student completes a full-year course in eight weeks by spending five hours with us on each of six days per week, has demonstrated very clearly that the plan has merit. There are few if any failures under this system, because the student is thinking of chemistry

all the time. He doesn't have to jump from a chemistry thought to a German thought, and thence to zoölogy or history. He can work and think in an orderly fashion. By extending the term from eight weeks to twelve weeks (the quarter system) he might carry a second subject and at most a third.

One educator has recently suggested the idea of permitting a student to select any subject in which he is interested, pursuing it to his heart's content and taking up related subjects, or others which serve as important tools or adjuncts, as he realizes their value. Occasionally we encounter a young man who is earnest and dependable and who is so deeply interested in chemistry and related sciences, that he can progress independently, almost without instruction. It would seem better to direct the undergraduate for several years, seeing that he learned to use the accessory tools as well as his chosen subject. He would be better off with a knowledge of physics, mathematics, and German when he had to use them during the course of chemical progress. Having passed a certain stage and secured sufficient breadth of training, he could safely proceed in the chosen field as his ambition prompted, and confer with his instructors from time to time. In other words, after the foundation is laid, we might resort to merely directing his self-education. This is, in a sense, the present procedure in our care of students engaged in graduate research.

Occasional special lectures of an inspirational type might be given. One might even give a full lecture course, making attendance voluntary. However, points which are now illustrated experimentally in lectures, either because of the cost or the dangerous nature of experiments performed, can be demonstrated by a laboratory instructor when his particular group is capable of properly interpreting them. In other words, special experiments are performed before groups which understand them, while at present all students in a large class attend a given lecture at one time, many perhaps failing to get the purpose of an experiment through inability to progress as rapidly as their fellows. Courses of fully illustrated popular lectures for students and others who merely want an introduction to chemistry for its broadening or cultural value can be offered. Nor is it planned to abolish lectures for some upper classes and graduate students.

The general recitation seems unnecessary. Some claim that it produces a competitive spirit. It is a wasted hour for one who knows his subject. Why not question the student occasionally in his small laboratory group and find out what he is doing and why? A comprehensive examination might be given from time to time, but even this would hardly be required in small classes where an instructor should know every student and his ability.

Will the general plan proposed above kill ambition and the spirit of competition? Hardly. Nothing so stimulates ambition as a task well

accomplished, and satisfaction and happiness constitute the student's reward. With numerical or letter grades abolished and credit granted only for the amount of work satisfactorily completed, the student gets a "pay-check," which in its appraisal of him in the college community, is a sufficient stimulus and urge to go on and on. When colleges and universities graduate such men and women, they can furnish a guarantee with each. It is self-evident that a larger and perhaps more mature instructional force is required to insure the success of this plan.

It is said that "The mills of the gods grind slowly." Our educational mills have been geared for rapid and uniform grinding and the human raw material is not suitable for these machines. Let us stop and realize that the individual should receive attention. Solemn contemplation will convince us that many failures might have been successes, had we but modified our methods of instruction to suit some boy or girl instead of following a "rigid system." The "yesterdays" have gone, and we are too late for them, but the "tomorrows" are still to come.

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THE OBJECTIVES in the teaching of chemistry are necessarily extremely diversified. They are influenced by the maturity of the students, by the function and even the location of the school in which chemistry is taught, and by the branch of the subject under discussion. The most important problems in the pedagogy of any field relate to elementary teaching—in chemistry, to its presentation in high schools and in first-year college courses. With your leave, I shall limit myself to the latter. The objectives of which I shall speak are attained more readily if the freshmen have already had considerable contact with the subject before admission to college, preferably through the medium of a high-school course, but the fundamental problem remains the same whether this is the case or not.

Even with these limitations, there are many phases of the subject which could be taken up. I wish to speak of chemistry, not as an isolated subject, but as a part of the general training which our colleges and universities are attempting to give to their students. This training has received very severe and apparently well justified criticisms both from within and from without academic circles. We are told that the average college graduate is neither educated nor efficient. Those who speak in general terms say that the college man, after leaving school, does not take his place as a leader in political, civic, religious affairs as he should; those who criticize specifically the students preparing for some specialty, such as

chemistry, do not complain that our students are lacking in knowledge, but emphasize the lack of ability to use the knowledge acquired.

These criticisms directed against our college graduates are similar to observations made by foreigners on American men and women in general. I have repeatedly heard well informed visitors to our country express the greatest admiration for the energy, the determination, the ingenuity, the honesty of our people, but have at the same time heard their astonishment at our lack of reflection. And while the qualities which we are said to possess so fully have been of the greatest value in the pioneering stage of our history, they will not lead to the greatest happiness nor the greatest success in the era upon which we are now entering—an era in which careful use of what we have left must replace the extravagant exploitation of what seemed unlimited natural resources. To solve our future problems, careful thought will be needed; to live happily and contentedly when our riches become more limited will require greater dependence upon intellectual pleasures rather than on those which are bought with readily acquired wealth.

In no country has the change from the pioneering age to that of husbanding of resources come so rapidly as in ours, and no people have had to adapt themselves to new conditions so quickly as ours. In this adaptation our schools must play an important role. It seems to me, therefore, that whether we are considering liberal education, the purpose of which is to develop as fully as possible the student's ability to draw from within himself the seeds of contentment and happiness and to function as a useful member of society, or whether we are discussing specialized professional training, we must set as our aim the development of intellectual power rather than the accumulation of facts. The acquisitive age is the high-school age—when the student has stepped beyond this period he should be equipped with a storehouse of facts large enough to be the basis for a career of generalization and of speculation.

It is interesting to note that the general criticisms directed against our modern college and university have revived an interest in the classics and humanities as contrasted to the sciences. I have no objection to these subjects in our curricula—I do not regret for a moment the fairly large amount of time devoted to them in my own education. But to reopen the discussion of the advantages of either humanities or sciences in contributing to a liberal education seems to me the height of absurdity. It is like a discussion I once heard carried on in all seriousness as to which topics in chemistry do, and which subjects do not contribute to a liberal education. Subjects and topics have nothing to do with the matter at all—any subject and any topic is the source of an education in the broadest sense of the word if the presentation is correct. The most cultured, the really educated man finds mental stimulus in every subject, in every fact

because he is trained to see each fact in its relation to thousands of others.

Now what I wish to maintain is that chemistry is peculiarly well suited to play an important role in the education of our younger students, whether they are professionally interested in the subject or not. It possesses certain phases susceptible of mathematical analysis, and thus gives opportunity for training in the type of reasoning employed in the most exact sciences. But not all reasoning is mathematical. And there are many relations in chemistry which today are based on a more generalized type of reasoning than that usually called mathematical. Finally, chemistry shares with other experimental sciences the educational advantage that it may be used to train students in the habit of checking conclusions against facts (which we call experiments). The social and historical sciences can afford this training but rarely—in our subject it is an everyday experience.

It is perhaps hardly necessary to point out topics in chemistry especially well suited to carrying out this type of training through chemistry. But I should like to point out how very often a slight change in the emphasis in teaching this or the other topic may entirely alter the nature of the benefit derived.

In the presentation of molecular and atomic weights it is, of course, necessary to acquaint the student with the methods of determining these quantities. It is obvious, also, that the success of our teaching must be tested by problems consisting of calculations of molecular and atomic weights from experimental data. But a student may be quite expert in making such calculations and yet know nothing about atomic weights. I believe that we often stress too much the doing of problems and neglect making sure that the underlying principles are appreciated. Few subjects are more fruitful in valuable training than this one. Consider what the comprehension of atomic weights means: first, the understanding of the reasons why an arbitrary unit could be made the satisfactory basis for expressing the weights of molecules although its value in ordinary measures was not known till recently; next, the modern basis of Avogadro's law; then the rational assumptions about the possible numbers of atoms in various molecules and the dependent deductions about the weights of the elements in unit volume of gaseous compounds; finally the check on the correctness of these assumptions by the facts. Here is a sequence of reasoning, experiment, deduction, and check which might seem to the superstitious to be made especially for the purpose of teaching students how to think.

Another point of extraordinary value is the comparison of properties of substances with their uses. I believe that descriptions of the uses of various chemicals particularly to students who have had a year of high-school chemistry can be greatly overdone. Suppose the student has for-

gotten the uses—is there any reason to suppose he will not forget them again, and what harm if he does? But it is training of the highest order to describe to the class some of the chemical properties of a substance, such as nitric acid or, even better, some less well-known reagent, and then to demand a list of possible uses. If the student is to become a chemist, the value of this type of training is obvious for a large part of his work will consist of the selection of proper reagents to accomplish a given purpose. But even if he is not to be a chemist, the training will be just as valuable for, after all, the selection of a man for a job, the selection of a plan for a house, yes, even the selection of a girl for a wife is a matter of making sure that the properties are adapted to the purpose.

Although there are hundreds of other examples I shall mention but two, chemical equilibrium and the periodic system. With freshmen, I prefer to treat the former topic in its simpler form—Le Chatelier's rule—because I believe that a general understanding of effects should precede mathematical treatment. But be that as it may, can you think of a more valuable training in logic, a more convincing demonstration of the value of exact experimentation and of the usefulness of checking up theory by fact than is afforded by the study of equilibrium as illustrated in the contrast between the methods employed in the synthesis of ammonia and of nitric oxide? Here the student can very clearly realize the folly of wild experimentation which lacks guiding principles, the value of forethought and well defined plans of search in contrast to haphazard guessing; here he can see the immense value of scientific theory to human welfare; here he can learn of the necessity of checking up every hypothesis by fact. How many failures in business, or even in life, are due to enterprises based on ill-founded hope instead of investigation, and how valuable a training which discounts baseless hopes and substitutes for them the habit of careful and patient inquiry.

The periodic system, on the other hand, provides another type of mental training. Many a college student is intellectually swamped by the mass of facts he has acquired and must continue to learn. The only hope of escaping from the wilderness is to find some means of coördination. Even if the periodic system were nothing more than an illustration of such coordination its value would be very great for the college student. But it is not sufficient to devote an hour or two to it at the end of the course, nor to mention it earlier and then to leave it severely alone. The facts of chemistry must be built on it as much as possible. And this treatment is of value in another direction; there are facts which do not fit well into the system. To arouse the critical spirit in our students, to show them the inadequacy of present-day knowledge and theories is but another way to make them think.

If, in my enthusiasm for the intellectual training of students through

chemistry, I have given the impression that I derogate the descriptive or factual side of the subject, I have not done what I intended. For chemistry is, of course, a science and, therefore, an orderly, systematic collection of facts. It is indeed a very practical science and that should not be lost sight of. But emphasis has repeatedly been placed in our discussions on this phase of chemistry, perhaps too frequently from the point of view of the particular class of students for whom I speak. It is on this account that I have spoken entirely on the other side—that of intellectual training. If our students can learn to think, if they can be trained to use what they know, if they develop judgment in our hands, we shall turn out a product both useful and successful, happy, and contented. And if that product is to be transformed into chemists, the transformation will be a very simple one.

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THE FINAL objective in all teaching is the production of an efficient citizen, one who is not only sufficiently able to provide for his own needs but also able and willing to contribute to the common betterment of society. There is need of special emphasis on the altruistic element in education since we are finding that statutes and punishments are not a sufficient check for the anti-social and criminal tendencies of some of our population. Education is the last hope of making democracy safe for the world.

In obtaining this final end of education lesser and more immediate objectives present themselves. In the vocation of teaching the foremost objective to be recognized is, that the *welfare and interests of the pupil are paramount.* It is necessary to re-affirm this readily admitted point, for, beginning with the high school the pupil begins to lose the center of the educational stage. The first definite withdrawal of emphasis from the pupil begins with the change from room-teachers to subject-teachers. From the force of circumstances which isolates the pupil from other teachers, the only teacher of a group of pupils must realize that the complete preparation of his pupils for life depends on him, at least for a time. Instead of bringing to the pupils all the values of a given subject that will make a well-rounded character, the teacher of a single subject tends rather to furnish them only with the information of the subject.

The language of education is literally saturated with the terminology of the subjects. The text-books, the syllabi, and the whole curriculum contain nothing else. Pupils point out their teachers more by subject than by their own names, teachers are sought for by subject name and the qualification most inquired into is the knowledge of subject-matter rather than the

ability to minister to vital needs of youth. These circumstances place undue emphasis on the subject as an end in itself, and they are responsible for directing the efforts of too many class-rooms toward the objective of filling up pupils with subject-matter as if they were empty vessels.

As found by the surveys of the past year the preparation for the teaching of chemistry in most of our colleges and universities is almost entirely the acquisition of subject-matter. After spending the college years gathering information and some further time is found for graduate study, we might expect that now the teacher will consider the organization and the best presentation of the subject-matter already accumulated. But no, the all too certain case is that the further study given is some sort of research for new and unknown subject-matter, as if there was extreme dearth of this already too plentiful article. The objection herewith made to research is, that for those who are to become teachers of chemistry, research of method rather than research of subject-matter would equip them much better for the vocation of teaching.

The great increase of chemical knowledge of the past 25 years has made the choice of subject-matter a point of increasing importance, particularly in fitting our teaching to the practical things of life. But when the best possible selection of subject-matter has been made the educational process is just begun. It is what is done with the information that makes it knowledge and confers effectiveness on the individual. Survey of the student body of high schools and colleges indicates that about 10% have an abiding interest in their studies. They will faithfully prepare assignments, and will persist in effort until understanding is obtained. They prove their desire for an education by the effort to obtain it. Given only such pupils, teaching would be a joyous vocation. The other 90% of the class range on down the scale of desire to approximately zero. A particular characteristic of this type of pupil is that they are soon filled up with information that they do not see immediate use for. For this 90% of pupils the first objective of the teacher is the creating of a desire for knowledge, information that functions in being useful. Compulsion is obsolete and not worth the effort. Academic methods of presentation, no matter how logically arranged, fail to interest because the pupil has not yet become proficient in the practice of rationality. In presenting the subject-matter of chemistry it is quite the accepted custom to consider a topic by the academic plan: occurrence, preparation, properties, and uses. I find few pupils interested in where it is found but most of them are decidedly interested in what it is good for. This is the pupil viewpoint and here we should begin with every topic. Of course text-books are not written after this fashion at present but the real teacher can present the topics in this way if he wishes. For example, if the topic "hydrates" is to be studied by the class it is introduced by the use of some such substance as a drying agent.

Then the nature of such substances may well be investigated by laboratory study, ending with the consideration of the formal text-book account or special reference. To reinforce this objective of interest at the beginning of the course some special topics from the achievements of workers in chemistry can be presented.

The next objective "training in method" or "method in training" will be introduced by a page of history of the American Chemical Society. Nearly two years ago some of my hearers were in Milwaukee participating in an afternoon's discussion of the training of the chemist. Speaker after speaker laid on more subjects with a generous hand, as each considered them useful or necessary, until it was certain that the chemist to be would have scant time to eat or sleep. Then the discussion further brought out the conclusion that after graduation the chemist would still be considered "raw material" from the stand-point of his immediate service to industry. Then as one industrial chemist after another told how his industrial work had carried him to fields far remote from his college researches, the education of a chemist was found to consist chiefly of the exercise of the mind in solving problems and not the storing of the mind with information. The subject-matter of his college researches had functioned as practice material but was now valueless. The skill acquired in using it, however, could still function. The case is the same for all pupils of the high school and college irrespective of the courses they are taking. The selection and association of ideas, the tracing of cause and effect, the judgments that fall from facts as a result of the discernment of their inner meaning; of such is the substance from which education is made.

If we know that the chief values of education lie in the exercise in thinking and training in method, let us as teachers of chemistry put this objective to the front and prove that we believe in it. We should definitely teach our pupils to hold the scientific habit of mind and apply its problem-solving power to all the questions that arise in daily life. The use of the scientific method has given us the marvelous development of material things, so let us use it more consistently. After the loss of the sense of sight the blind person by necessity develops the other senses to make up the deficiency of sight. Then our senses may be sharpened in like degree if we will train them as he does. We know it, but somehow we do not do it. As our pupils see, smell, touch, taste, and hear, let us see to it that the thinking to form a mental image goes with it. Then there will be sense training. Because we teach too many topics we do not have time or do not take the time to think about the relationship of facts and build them into larger units of knowledge. The discussions of a minimum list of fundamentals will bring an enormous improvement in teaching if the topics are so reduced that they are studied more scientifically.

Every class in chemistry prepares hydrochloric acid in the laboratory as

well as several other acids during the course of the year. The usual result is that the pupils think that each acid must be prepared by a different method and each one learned by itself. In this way pupils make a subject difficult. The business of the teacher is to show the pupils that all acids are prepared in the same fundamental way regarding materials used and the method depending on the properties concerned. When a pupil, from his knowledge of how acids are made in general, can outline a method of the essentials in the preparation of an acid that he has not studied, he feels the power of knowledge, he acquires confidence in his ability to do things, and becomes interested in learning. He has followed the scientific method in deductive reasoning. This is just one sample of how chemistry has been taught in an effective manner. Every topic can and should be presented in the same general way. Through the guiding objective of the scientific method the interest, enthusiasm, and appreciation for chemical knowledge grows in the pupil for the facts of chemistry are related and organized in the science of chemistry, the subject that offers the greatest educational opportunities of any subject in the curriculum, and will take the foremost place in the near future *if the teachers of chemistry so wish.*

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THE WORDING of the title might justify me in treating the subject in its broader aspects, but others have done this better. For instance, J. O. Frank of Wisconsin has consulted authoritative sources and compiled the following as things that we, as chemistry teachers, are trying to do: (1) to instruct our students, (2) to train them, (3) to inspire them, (4) to give them the discipline of scientific method, (5) to give them the power to interpret, (6) to aid in exploration and guidance, and (7) to help them find recreation in chemistry.

H. R. Smith in the JOURNAL OF CHEMICAL EDUCATION for July, 1925,[1] reports that the Chicago Association of Chemistry Teachers has formulated the following objectives in teaching chemistry: (1) to bring about as soon as possible the pupil's appreciation of training in scientific method and chemical knowledge, (2) to teach pupils the understanding and use of the scientific method of solving problems, (3) the correlation of facts to build a unit of knowledge (a principle or law), (4) application of principles and laws to new situations in the solving of daily problems (vocational and leisure time education), (5) coöperation in community groups to promote human welfare, and (6) development of moral law and religious attitude in daily life.

[1] THIS JOURNAL, **2**, 585–7 (1925).

But I am supposed to represent the high and other preparatory schools of the eastern states and to bring to you some ideas of the objectives governing teachers in the east. This is somewhat hard to do because conditions vary so from large city high schools with the best of equipment and conditions to small country high schools with almost no facilities. It is probably fair to say that the objectives of eastern teachers are not far from those mentioned above, thus showing that we are all of one large family in the chemical education problem. Many eastern teachers do have as an extra objective fitting their students for the entrance examinations to higher institutions of the non-state university type.

One very encouraging aspect of the situation is that during the past two decades chemistry teachers in high schools have been waking up, striking out for themselves, trying new ideas of their own, and breaking away from the college entrance requirements in an effort to make the teaching of secondary-school chemistry a profession by itself.

As an example of this may be mentioned the activities of the New England Association of Chemistry Teachers, which has now for over twenty-five years been holding without break from four to twelve meetings per year and printing full reports of the meetings.

Four problems stand out prominently in the high-school chemistry teacher's job: (1) improvement in text-book writing, (2) the best handling of the college preparatory and of the non-college preparatory classes, (3) better teaching, and (4) the correlation of the laboratory with the rest of the work.

The text-book is a serious problem. Many of the best sellers are built too plainly on the requirements of the College Board and on the New York Regents, two very powerful agencies in the East in determining what shall be taught in high school. All deductions from tables of per cent of text devoted to theory, description, applications, etc. (such as those by Cornog and by other investigators) must be made with the above in mind.

Inconsistency in existing texts is well illustrated by the fact that six of the widely used texts give six different formulae for the laws of Boyle and of Charles, four different methods of solving stoichiometrical problems, and display a woeful lack of accuracy and consistency in definitions of terms.

It is refreshing to see books appearing which are written by high-school teachers conversant with the situation and which are built around the needs of the pupil. One has very recently appeared, written by a teacher on the Atlantic coast, one by teachers of the middle states, and one very admirable text by teachers of this immediate Pacific coast region.

Should students not going to college be grouped with the college candidates and be given the specialized training required of the latter? Where 90 per cent of the students do not go on to college, this is a serious problem, and it has given rise to courses of widely differing character and content.

It is now recognized that both classes of students need the fundamentals of the science. It is the aim of the A. C. S. Outline of High-School Chemistry and of the new revision of the College Board Chemistry Requirements to reduce the amount of the essentials so that all students can get these in about two-thirds of a year. The rest of the year can then be devoted to such phases of the subject as are particularly suited to the personnel of the class or the nature of the locality. (See the first and second objectives governing the A. C. S. Committee on Chemical Education on page 87 of the May, 1924, issue of the JOURNAL OF CHEMICAL EDUCATION.) There is a growing tendency on the part of colleges to favor such a plan as it will obviate a considerable amount of reteaching. It will also help solve the high-school chemistry teacher's problem, and will give more credit for work well done in high school.

Better teaching goes hand in hand with better teachers. In too many schools the chemistry teacher has to teach too many other subjects, and sometimes he has not specialized in chemistry in college. Some authorities are beginning to recognize this point, but much remains to be done to remedy this serious defect. B. S. Hopkins has well said: "A good teacher is the most important factor in any chemical course of study. Expensive laboratories, elaborate equipment, costly reference libraries, superior textbooks, and skillfully arranged courses of study are of little value in the teaching of chemistry unless they are presided over and administered by the mind of an individual who knows and loves chemistry and who has some skill in the science and art of imparting his knowledge to others." For the benefit of such teachers whose college work did not fit them directly for the profession of high-school chemistry teaching, summer courses are of great value. That the teachers value these opportunities is shown by the fact that the attendance at such a course in one large eastern institution jumped from about 10 last year to nearly 50 this year.

As to content implied in better teaching these items might be mentioned. Teach general principles so far as possible and let each new experiment or new reaction illustrate some general principle. H. F. Davison says that lecture experiments should "drive home general methods and general principles as much as possible" instead of being merely spectacular.

Further, teaching too many isolated facts leads to confusion. Therefore group the facts as much as possible. Use the Periodic System if you love this tool. Some think the electromotive series or displacement series a better aid, in that it teaches or classifies among many other things (1) the occurrence of metals as free or combined, (2) general methods of metallurgy, and (3) the reactions between a metal and acids.

If you teach much on metals, group the metallurgy around the four general methods of extraction, instead of letting the student get the idea that

each metal has a method of extraction all its own, very different from that of all other methods.

The proper function of the laboratory and the correlation of its work with the text and recitation was recently considered of such importance by the New England Association of Chemistry Teachers as to warrant a voluminous questionnaire covering about 200 specified items. The result was a 45 page report printed by the Association giving a careful analysis of the answers from 100 representative teachers. It is impossible in the time at my disposal even to summarize the results of this questionnaire. Instead let me simply urge the following as highly desirable: (1) Laboratory work to accompany the text-book, for unfortunately there still exist schools where chemistry is taught without laboratory work, (2) the proper order of laboratory and text-book work, (3) the proper proportion of time devoted to each, (4) the most appropriate and efficient selection of experiments to avoid play in the laboratory and to form the proper underpinning for a body of chemical knowledge, (5) inclusion of the right amount of quantitative experiments, (6) more educative guidance by the teacher in the laboratory, (7) sufficient time for the teacher to prepare for the laboratory work, (8) development of scientific methods of thinking or reasoning rather than allowing the laboratory period to be a period of mechanical test-tubing, (9) giving full clock hour credit to both student and teacher for the laboratory period, because an hour honestly and faithfully spent in laboratory work and properly supervised, guided and quizzed is worth an hour to both teacher and pupil, (10) a fair inspection of the note-book, and (11) the recognition that solid chemical knowledge is best gained from personal contact with the chemicals and their reactions followed by proper digestion of the facts thus obtained.

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Tuberculosis Germs in Books Live Long Lives. The best books may be a great source of danger if a careless tubercular person used them last, for Drs. Touchais and Moureau have found that the germs live on the pages for four or five months. The question is regarded as of practical importance because it shows the necessity of disinfecting books circulating in public schools or libraries.

Drs. Touchais and Moureau made tests to see how long the germs from tubercular sputum and from a laboratory culture kept their virulence when smeared on the pages of a large number of books kept in all sorts of conditions such as are found in homes, schools, and libraries. The germs from sputum were the hardiest and were able to infect guinea pigs with the disease even after four and a half months. The germs from the laboratory cultures were still active after two months, but in about three months they were impotent.—*Science Service*

SOME PROBLEMS OF CURRICULUM AND OF METHOD OF INSTRUCTION IN HIGH-SCHOOL CHEMISTRY

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Professor Powers' present article was not among those presented at the Objectives Symposium at Los Angeles but his consideration of teaching problems is so closely linked with the question of objectives that his paper should be grouped with the foregoing collection. As usual, he supports his contentions with facts derived from a number of careful experimental investigations.

I. The Objectives of Subject-Matter

The Disciplinary or Training Aim

One of the earliest attempts to define the values which may come from instruction in high-school chemistry is the one made by Chester Dewey in an address which he delivered before the American Lyceum in 1833 and which was published in one of the educational journals of that day.[1] His lecture was a plea for larger provision for science in the program of the "common schools." In support of chemistry he maintained that the knowledge or informational value was in itself sufficiently important to afford a justification for extension of instruction in chemistry to pupils in the common schools. He explained how a knowledge of chemistry contributed to the understanding of problems of agriculture, mining, metallurgy, tanning, and other industries and he made the direct informational value of the subject the main support for his plea. It appears, however, that he recognized the claim for disciplinary value which had been made by those who supported the subjects already in the program of studies, and in order to strengthen his case for chemistry he urged that in addition to the direct values from the knowledge of the subject-matter of chemistry certain indirect values attended its study. His claims for the indirect or disciplinary values of chemistry are closely similar to those made by disciples of the theory of formal discipline for other subjects and which have persisted in educational literature until recently. He said:

1. The study calls into efficient action the power of discrimination. The mind is trained to minuteness of examination, and to the improvement of its power of seeing and making distinctions. Thence the mind proceeds to generalizations.

2. The relation of one part to another of an object must be observed. The process of examination is fitted to induce the habit of attending to the relation of things, and of creating the power to consider the relations of things in all cases.

[1] Chester Dewey, "Natural Science in the Common Schools," *Am. J. Educ.*, **5**, 248–53, 304–11, quoted in the monograph by S. R. Powers, "A History of the Teaching of Chemistry in the Secondary Schools of the United States Previous to 1850," University of Minnesota, Contributions to Education, Current Problems No. 13 (1921).

3. It leads to the adoption of system, arrangement, method, classification. Consider the multitude of facts in Chemistry, isolated and independent, until they were reduced to systematic order by some of the master spirits of modern times. This system, order, and arrangement is now a part of the subject itself, and the study cannot be prosecuted without this part of the logic being practically enforced upon the mind.

4. It stores the mind with objects of thought and interest, and prepares it to increase their number.

Mr. Dewey admitted that these values were not the most obvious and his evidence to support their importance would hardly be accepted by educational workers today. In support of these claims he stated that he knew of several instances of young men who had, by an attention to natural science, "became arrested in their mad career to intellectual and moral ruin." Contemporaries and forerunners of Mr. Dewey found most support for the study of science in the functional value of its subject-matter but from his time until comparatively recently there has been increased emphasis upon the importance of the disciplinary function. The prominence of the theory for formal discipline in the minds of educators during the formative period of the chemistry course is assurance that those who shaped the content of the course were guided by it.

During recent years this theory has been subjected to careful analytical and experimental study and the results from these studies have put into question much that has been claimed for it. The older statement of the theory as a corollary to the "faculty psychology" is now wholly discredited. It is established, for example, that general transfer is not automatic and inevitable. Transfer of ability from one field to another is possible but will result only when certain conditions are satisfied. "First the knowledge, power, or ability must be possessed in one field. Second, it must have similarity of application in another. And, third, the learner must recognize the common elements and the possibility of transfer." In other words, transfer from one learning situation to another is possible only when the two situations have elements in them which are identical and when these elements are made evident to the learner. The solution of certain types of problems in algebra, for example, makes demands for ability to use certain elements which are identical with some demanded for the solution of problems in chemistry. Problems of ratio and proportion are illustrative of the case in point. Ability to use these elements will transfer from algebra to chemistry provided the ability is mastered in algebra and provided the elements in the algebra problem which are identical with those in the chemistry problem are recognized by the learner.

If the study of chemistry, or any other subject, is to find support for its training or disciplinary value it is because the study of it develops many abilities which are identical with those demanded for the study of other sub-

jects or which are useful in activities which one meets outside the schoolroom. This point of view which finds support in experimental studies is not at all in harmony with the one which prevailed earlier and which served to guide those who were instrumental in constructing the present course of study in chemistry. Chemists were slow to drop the phlogiston theory even after pioneer investigators had established its falsity. They are even slower in their rejection of falacious theories of education.

The Knowledge Aim

A second objective is to impart to students a broad knowledge of the field of chemistry. For the accomplishment of this, the texts in use are veritable encyclopedias of chemical information. The text of today has had an interesting evolution. When chemistry was first given a place among the subjects of instruction in secondary schools and colleges the bulk of chemical information available was not large. All of chemistry that was known and organized as science could be included within a small text. But with the development of the subject has come enormous accumulations of knowledge. Many new fields have been opened. Much of the new knowledge has been added and much that was in the older books has been retained until the accumulated material sets a task for high-school students which is, for them, nearly insurmountable. Of the two text-books which are most widely used, one uses 386 terms which are names of elements and their compounds; the other uses 435 such terms. Each contains equations for a multitude of chemical changes and descriptions of many chemical processes.

Recent studies of the amount of learning show that students obtain but poor mastery of the great mass of material which constitutes the body of their instruction. Data available[2] reveal some interesting facts relative to what students do not learn. From reference to illustrative cases the reader may hazard a guess at what they do learn. Test items which may be grouped under some 14 divisions were given to a large number of students who were just completing one year of study of chemistry and the percentage of them who answered each item correctly was computed. Tests of knowledge of composition showed that less than 50 per cent knew that proteins differ from other food stuffs in that they contain nitrogen; that the most important iron ore is iron oxide; that the sensitive agent on blueprint paper is a compound of iron. Less than 50 per cent knew the composition of each of the following: limestone, water gas, plaster of Paris, cotton fiber, silver coin, Epsom salts, and other substances. Some of these were answered correctly by less than 25 per cent.

In the same study it was found that less than 50 per cent knew that commercial glucose is made from starch; that the alkalinity of sodium car-

[2] Brief reference to this investigation has already been made in THIS JOURNAL.

bonate is due to hydrolysis; that the most of the supply of oxygen used in commerce is made from liquid air; that aluminum is prepared by electrolysis; that the Haber process is used for the manufacture of ammonia; and that sulfuric acid is used extensively as a dehydrating agent.

Less than 50 per cent were able to compute from the formula the number of grams of water in 250 grams of copper sulfate; to do the simplest calculations involving the gas laws; and computations involving the law of multiple proportions.

Equations were particularly troublesome. It occasions some surprise to learn that among those which are very difficult for high-school students are: laboratory preparation of hydrogen sulfide using ferrous sulfide; precipitate test for carbon dioxide; action of sodium upon water; laboratory preparation of ammonia using ammonium chloride and slaked lime; and the preparation of oxygen from potassium chlorate.

Items which were so difficult that they were answered correctly by but 50 per cent of the entire group were answered correctly by a much smaller percentage of the less competent students. Many of the items of this degree of difficulty were answered correctly by 20 per cent or less of the students in the less able one-half of the entire group.

The percentages are of the total number of students in all the schools which coöperated in the investigation (totaling about 50 schools). A study of the results from individual schools reveals the fact that there is an enormous difference between the scores made by the students in the schools with the highest median scores and those in the schools with the lowest median scores. In many of the schools, and for the most part the smallest ones, the students showed poor mastery of even the simplest tasks included in the tests; while in other schools most of the students were able to do a large percentage of the tasks correctly.

The tests were also administered to a group of individuals who had studied high-school chemistry for one year and who had been out of school for some time. For the different individuals the period of time ranged from three months up to several years. Those who had been out of school three months did much poorer on the tests than those who took them at the end of a year of instruction. Those who had been out of school more than one year were able to do but few indeed of the tasks. This investigation shows that the majority of students gain no mastery of a large amount of the material contained in the commonly used text-books and that much of what is learned is rapidly forgotten. Two studies[3] made, each independently of the other, show similar results and support the conclusion that the knowledge aim is very incompletely accomplished.

[3] Gerry, "Test of High-School Chemistry," Harvard University Press, and Powers, "A Diagnostic Study of the Subject-Matter of High-School Chemistry," Teachers College Contributions to Education, No. 149.

The Preparatory Aim

A third objective of instruction in high-school chemistry is college preparation. Data available relative to this one suggest that much of the support for it is of doubtful validity. A large proportion of the students who study high-school chemistry will not enter college and of those who do a large proportion will not study college chemistry. For these this objective can hardly be supported. Its validity as commonly interpreted is questionable even for those who do enter classes in college chemistry.

One of our students[4] has recently prepared a test to cover the material outlined in the first division of the syllabus for first-year college chemistry prepared by the Division of Education of the American Chemical Society. This division of the syllabus includes laws, theories, and calculations. In the traditional courses in high-school and college chemistry this subject-matter is, for the most part, taught during the first semester. The test consisting of 95 items was administered to students in three selected high schools and in three colleges. The results show a large overlapping of the scores of high-school and college students. One high school excelled one college and practically tied with another college. Thirty-one per cent of all the high-school students were above the median of all the college students. If students from two of the high schools were to enter either of two of the colleges and study chemistry they would be associated with students who, as a class would do no better quality of work in the subject-matter tested than they had already done in high school. The students from the high school with the highest median and a considerable number of those from each of the other high schools must enter the "best" college in order that they may have a chance to excel the record they have already made. If these results are indicative of the standards of work done on each of these levels, it would seem nearly as reasonable to ask students to attend college in order that they may prepare for the study of chemistry in high school as that they attend high school in order to prepare for college chemistry. The high schools selected for this investigation were selected because they were known to be giving excellent work in chemistry so that these results do not furnish an adequate basis for generalizations. However, a fact which may have been anticipated seems to be established, namely, that the standards of work done in the best high schools is quite on a par with that done in freshman classes in many colleges. The question needs further investigation for the purpose of establishing a more intelligent basis for giving recognition for the work done in the better high schools, and in order that the foundational background upon which the freshman college course may be built may be revealed to college teachers.

[4] Fred C. Mabee, "A Test of Achievement in College Chemistry and Results Obtained by Its Use with Both High-School and College Classes." To appear in THIS JOURNAL.

The aims just discussed are the ones which more than anything else guide the instructional efforts of chemistry teachers. Neither is being effectively accomplished and, as commonly conceived, neither is worthy of the potentialities of the subject. The common interpretation of the disciplinary or training objective is one which has developed from a faculty psychology. The knowledge or informational aim implies the acquisition of an organized and extensive knowledge of systematic chemistry. This is the information which the text-book presents. This objective is but poorly accomplished by students on both the high-school and the college level and for two reasons. The first, there is an attempt to teach a multitude of facts without regard for their relative importance and but little regard for their relative difficulty. The second, there is "no provision for repetition or for planned recurrence either with definite practice or in varied and stimulating settings."[5]

The encyclopedic character of text-books is not peculiar to chemistry but in this subject it may occasion greater difficulty for the reader than in others for the reason that a larger proportion of the text material is unrelated to the experiences of the layman.

Chemistry teachers may well raise the question—"What knowledge is of most worth?" It is in vain to attempt to teach it all. Much of what is taught and learned is unrelated to the life activities of any one other than the specialists and is soon forgotten with no appreciable loss. Is there a serviceable subject-matter of chemistry? Is there a knowledge of chemistry which is so important that it may not be forgotten without appreciable loss? Manifestly, yes, and it is the task of workers in chemical education to outline it and to teach it.

Subject-matter values must be defined as values for some one. Most of those who study chemistry in high school are not looking forward to a career in chemistry. Most of them will graduate from high school, some will go to college, and almost all will develop into successful men and women. The pertinent question is, what knowledge of chemistry is needed by successful men and women who are not chemists, and a large contribution to the problem of course of study in chemistry will be made by its answer. These successful individuals will read the science of the press and of the literary journals. One is better educated if he is able to read this material critically. A supportable objective is then to give such instruction as will assist in the interpretation of the science in the reading material which has wide circulation. Enough progress has been made in the analysis of this material to indicate its fruitfulness for further study.

Again, chemistry may afford a background for the interpretation of many questions of citizenship, particularly those relating to public works.

[5] Quoted from H. O. Rugg, "Objective Studies in Map Location," p. 3.

What should the educated citizen know about the chemistry of water purification, the gas industry, utilization of coal and liquid fuels, building materials, etc.? There is need for an analysis of these industries for the purpose of seeking an answer to these questions.

There are other fields of which analysis should be made in our search for the chemistry which is of most significance to those successful individuals who are not chemists. Chemistry furnishes a background for the interpretation of natural laws such as those of ultimate composition, indestructibility of matter, nature of chemical composition, interrelation of chemical elements, etc. These are essential elements of an intelligent philosophy of life. There is chemistry which is related to health. This implies some knowledge of the composition of drugs and medicines, and of their physiological effects; and knowledge of principles of sanitation. There is industrial chemistry, a knowledge of which is desirable for the ultimate consumer.

In brief, the course of study in chemistry should be found in an analysis of the needs of successful men and women. A course with such a content would meet all the requirements placed upon the present course. It would be such that it would function in the lives of men and women, and the generalizations would not be forgotten. Such a course would contain many "elements" for learning which are "identical" with elements in problems which arise outside the school. It would, therefore, be best adapted to the accomplishment of the training or disciplinary value. It would deal with problems which are close to the students' interests, its problems would be real and as a consequence would be better adapted for training in thinking which involves chemical concepts. The course best adapted for training in thinking would be of largest value for college preparation. In summary, the primary objective of the high-school course in chemistry should be to impart such skills, abilities, knowledge, etc., as the field of chemistry may contribute, which are useful in the affairs of successful men and women. It is an incident (however, an important incident) that such a course shall be well adapted for the accomplishment of training values and for college preparation.

The reorganized course will not be radically different from the one now in use. I do not know just what it will be, for the questions which have been raised have not been answered. It is likely that the most radical change will be the elimination from the present course of material which may be shown to be of little value. New material will be added but the present plan of organization of texts need not be radically changed. It will still be necessary to teach the important laws, principles, and theories and the chemistry of the common elements. But the goal of instruction will be to equip boys and girls for living and not simply to prepare them to pass an examination.

II. Objectives of Laboratory Instruction

The original support for laboratory work was for its training value. It was claimed that laboratory work provided the facilities for training in the scientific method of work. But this objective for laboratory work is open to the same criticism as when stated for text work. Current practices in the high-school laboratory can hardly be supported by it, for as stated earlier it seems to be established that that subject-matter and those activities are best adapted for general training which present the largest number of contacts, or contain the largest number of elements which are identical, with those which occur in situations which arise outside the classroom or laboratory. It is hard to think of an instructional activity which is so foreign to life experiences as some of those which prevail in a modern chemistry laboratory. There can be no training except as it is training to do something. The training furnished by laboratory work may be of value for those who are looking forward to a career as scientific investigators but for our successful men and women who are not specialists its training value must be small.

The syllabus committee of the New York City Chemistry Teachers' Club suggests another function for laboratory training. Their statement is, "The underlying principle of laboratory work is illustration, not proof. . . ., the laboratory should aim at giving concepts instead of printed symbols." For the accomplishment of this objective, laboratory work may be presented as demonstrations or as individual pupil work. In recent investigations efforts have been made to test the effectiveness of each of these methods. Results from an investigation made during the current year by one of our students[6] suggests the conclusion that either method is equally effective. Something over 20 high-school teachers in as many different schools coöperated in this work. Ten exercises taken in consecutive order beginning with number two from the laboratory manual by Brownlee and others were used for the experiment. In one school, exercise number two was done by the ordinary method of individual laboratory work; in a second school this exercise was done by students working in groups of two; and in a third school the exercise was presented as a teacher demonstration. During the next laboratory period those who did exercise two by the individual method did exercise three by the group-of-two method and those who did exercise two by the group-of-two method saw exercise three as a demonstration and those who saw exercise two as a demonstration did exercise three as an individual exercise. In similar manner the method was rotated until the ten exercises had been covered. The effectiveness of the work was tested, using the same sets of tests in each school. The results show that when evaluated in terms of amount of learning it makes little

[6] W. W. Carpenter, "Some Problems in the Administration of High-School Chemistry," Teachers College Contributions, No. 188 (1925).

difference which of the three methods is used. There was a small margin of difference in favor of the demonstration method over the individual and a somewhat larger margin of difference in favor of the individual method over the group-of-two method. The demonstration method was most effective and the group-of-two method was least effective, but the differences were small. Results from the study of laboratory work in physics[7] and in biology[8] supplement those just reported for chemistry.

These investigations are a challenge to those of us who advocate instruction in chemistry by the individual laboratory method. It should be clear that these investigators are making comparisons with laboratory work as it is now given and that they have tested only the accomplishment of the informational objective. If present methods of laboratory work cannot be improved and if the only objective of laboratory work is acquisition and interpretation of information, then it seems the individual laboratory method may well be abandoned and the demonstration method substituted. It is cheaper and consumes less time. But it would be unwise to consider the abandonment of the method until investigations have been made looking toward the improvement of technique, and until investigations have been made to determine the possibility of accomplishing other and possibly more significant objectives. The abandonment of the laboratory method means the abandonment of the theory which has guided practice in instruction in science. Practices are too well established to consider their abandonment until they are more thoroughly tested.

Another problem of laboratory instruction relates to note-book work. I recently did the exercise of the preparation and properties of oxygen following the traditional procedure before a class made up, for the most part, of experienced chemistry teachers. The students were asked to write notes on the exercise following the method which they required of their own high-school students. Most of the students wrote two pages or more of notes. The minimum time required to write these notes could hardly have been less than 15 minutes and this would allow almost no time for thought concerning content. Two to three minutes of the teacher's time are required to read the notes from a single student. For the teacher who teaches 100 students, upwards of 5 hours are required to read the notes and this will not allow time for constructive (or destructive) criticism. It is reasonable to question whether the educative value of note writing is large enough to merit this expenditure of time on the part of both teacher and pupil. It is a reasonable hypothesis that the teacher's class would profit more from five hours of his time spent in preparation of new ma-

[7] Kiebler and Woody, "Individual Laboratory versus the Demonstration Method in Teaching Physics," *J. Educ. Research*, **7**, 50–58 (1921).

[8] Cooprider, "Oral versus Written Instruction and Demonstration versus Individual Work in High-School Science," *Sch. Sci. Math.*, **22**, 838–844 (1922).

terials of instruction than from five hours of his time spent in reading notes. The case for laboratory notes cannot be considered as established until more adequate objectives for laboratory work have been defined and until some measurement has been made of the learning which comes from it. This is a problem for experimental teaching.

Summary

1. Curriculum studies should be made for the purpose of determining the materials of instruction which will contribute most to complete living of educated men and women. What do these individuals need to know about the chemistry of public utilities, industry, health and sanitation, and what chemical theories and laws can function in their thinking? By experimental teaching, standards for accomplishment in this subject-matter should be established.

2. Studies in method should determine most effective means of gaining mastery of that chemistry which may be considered to be fundamental. How may the student most effectively gain mastery of formulae, equation writing, calculations, essential chemical processes, etc.?

3. Laboratory studies should clarify the objectives of laboratory work and develop effective methods for accomplishing these objectives.

4. Current practices in laboratory note-book work should not be accepted as valid. The possible values should be analyzed and tested.

Germans Plan Exploitation of New Helium Source. A new way of getting helium has been suggested in Germany by Dr. Kurt Peters of the Physical-Technical Institute of Berlin. It is to be distilled from radio-active minerals used in various industries, and mainly from monazite sand, which is made into Welsbach mantles. Although it has been known for a long time that these minerals give off helium when heated, the gas has never been recovered commercially. Dr. Peters claims that it is the largest source of helium in Germany at the present time. He estimated that a production of from fifteen to twenty thousand cubic feet is available annually, which is a thousandth as much as was lost in the Shenandoah disaster in one day.

While this amount will not be sufficient for use in dirigibles it is expected to suffice for technical purposes. Helium has been most difficult to obtain because the United States, which is the only country in the world producing the rare gas in large quantities, has stringent export laws prohibiting its sale to foreign countries except with the sanction of the War and Navy Departments.

Dr. Meissner, also of the Physical-Technical Institute in Berlin, obtained about 25 cubic feet of the gas from a neon-helium mixture. This was obtained as a by-product, in the manufacture of liquid air used in Berlin refrigeration plants, after months of distillation in the laboratory. It is estimated that this amount of helium came from about five million cubic feet of air. The new method of recovery from minerals instead of from air will yield greater quantities and purer helium, according to Dr. Peters.—*Science Service*

THE LIFE AND CHEMICAL SERVICES OF FREDRICK ACCUM*

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Chapter III

Industrial Chemist and Early Investigator of Gas Lighting

Accum's growing reputation as a chemical operator and analyst resulted in a great demand for his services by manufacturers. As a general analytical, consulting, and technical chemist he soon became the best known man in London. The records of the time mention his name constantly as an expert in important chemical cases. A contemporary, in writing of Accum in 1820, says:

> He has become among manufacturers the most popular consulting chemist wherever chemical aid is desired and it is perhaps unnecessary to state that he is well known in our public courts of justice and in the Committees of Parliament where he often appears to explain chemical processes or to report and give evidence on subjects connected with chemical science.

Accum was frequently called upon to perform chemical work for the government. One of the first services of this nature that he rendered is an early illustration of the application of chemistry to warfare, of which Silliman has left the following account:

> Accum assured me that he had been employed by government to contrive some infernal machination with which to blow up and burn the French Flotilla, then assembled at Boulogne for the invasion of England. He accordingly, as he said, arranged phosphorus and chlorate of potassa in contiguous divisions of tin canisters. These were to be projected upon the flotilla and the contrivance was such as to mingle in the act of discharge these most explosive materials which, if once in contact with the ships, would destroy them by explosion and by a fearful combustion which nothing but submersion could extinguish. Happily, the project failed—the canisters exploded in the air short of their object and, as the flotilla never left the harbor, all was well in the end—while Trafalgar dissipated the dream of French invasion.

The industrial side of chemistry seems to have interested Accum at a comparatively early period. Shortly after the opening of his laboratory in Compton Street he did some chemical work for a soda factory and, in the August number of Nicholson's for 1802, he contributed a paper upon "The Methods by Which Soda Is at Present Prepared for the English Market." Among other early investigations of this character should be mentioned a research which he carried out in 1804 for the potters of Staffordshire in a study of new minerals for manufacturing earthenware.

But the work in technical chemistry for which Accum is best remembered is that pertaining to the introduction of gas lighting. In the winter of 1803 and 1804, a German, F. A. Winsor, gave the first exhibition of gas lighting in London at the Lyceum theater, although William Murdoch

*Continued from THIS JOURNAL, 2, No. 10, 829–851.

and others had given practical demonstrations of this new method of illumination outside of London several years before. Winsor obtained a patent for his process in May, 1804, and immediately attempted to incorporate a company for lighting the streets and buildings of London. Previous to this, Accum had interested himself in the chemistry of gas production and, at the request of the promoters of the new company, conducted a long series of experiments which he afterwards described, in his testimony as chemical expert, before committees of the House of Commons and the House of Lords.

As this is one of the first hearings pertaining to industrial chemistry of which there is any record, a few extracts from Accum's testimony before the Committee of the House of Commons on May 5 and 6, 1809, are given. Accum appeared in the interests of Winsor, whose application for a charter from the government was contested by Murdoch.

Mr. Accum (*examined by Mr. Warren*).—I have been employed in making experiments on the extraction of gas or inflammable air about six months, though I have made experiments for Mr. Winsor's Committee twelve months ago; I have seen it made by Mr. Winsor, and by his stove and the effect produced by this gas; it may be conveyed through pipes, like any other fluid, from place to place. If an aperture is made in the pipes, the inflammable air issues out of it, and if a candle be applied to it, it will take fire, and will continue burning as long as there is a fresh supply of inflammable air; it is impossible for it to take fire, unless it communicates with the external air; it cannot take fire spontaneously. There is not any smell in the gas at the time of combustion, if the combustion is properly effected. There is not any danger of this gas bursting the pipe in which it is contained, in the manner I have seen it generated by Mr. Winsor and conducted through the pipes constructed by him; but if more gas is liberated than could escape through an opening, there would be danger of bursting; if there was no reservoir the gas could not accumulate; but there is no reservoir in Mr. Winsor's plan; the pipes contain the gas without a reservoir.

Future experiments showed, however, that Winsor's plan to do without a gas reservoir, while successful perhaps upon a small scale, would not answer the requirements of city illumination.

Considerable attention was given at this hearing to Accum's account of his experiments in the utilization of the by-products of gas manufacture. He produced specimens of carbonate of ammonia, sal ammoniac, caustic ammonia, sulfur, oil, tar, asphaltum, etc., which he had obtained, and discussed methods for their utilization.

Mr. Accum (*examined by Mr. Harrison*).—I have found from experiments that one hundred pounds of coal yield from four to five pounds of tar of the consistence of treacle or of a thick oil. The tar yields a certain quantity of volatile oil and a residuary matter resembling asphaltum. It answered all the purposes of the asphaltum procured in the market. I have given it to japanners and have seen specimens of what it produced and it looked very beautiful. I have dissolved it in turpentine to procure a varnish and it will bear an excellent polish.

The experiments of Accum upon the distillation of coal tar are important

for they represent the first crude efforts for the utilization of this important chemical by-product. Two hundred pounds of tar according to Accum's experiments yielded fifty-three pounds of a volatile oil which he stated could be used as a substitute for turpentine in painting and varnish making and could also be burned in lamps. The composition of Accum's volatile coal tar distillate, with its complex mixture of benzene, toluene, xylene, naphthalene, phenol, and other ingredients, remained an unanswered problem until Hoffmann began his investigations upon it in 1843. Benzene, the principal constituent of this distillate, was an unknown substance until Faraday announced its isolation, in 1825, from the gas obtained by the destructive distillation of whale oil, under the name of bicarburet of hydrogen.

The illuminating power of coal gas as compared with candle light was also investigated by Accum.

Mr. Accum (examined by Mr. Warren).—I have made experiments upon the intensity of this light, or the quantity of light which it gives and compared the light produced by a flame of gas with the light produced by an equal flame of a tallow candle. The way in which I brought the flames to an equal size was this: I constructed an apparatus with perforations, which permitted the gas to flow through it in such quantities only that when set on fire the flame thus produced measured, as near as could possibly be ascertained, the same size as that afforded by another luminous body, a candle I made use of, which was given as a standard; that was the plan I adopted and the same experiment I made with Mr. Winsor's apparatus. In order to obtain some knowledge of the respective intensities of the two lights, it may be accomplished by judging of the intensity of the shadows which these bodies cast, when they are suffered to fall with a certain obliquity upon an illuminated surface. That is what is called Count Rumford's experiment: it is well known; the result of that experiment, the comparative effect of those two flames of equal size, is nearly as three to one, provided the combustion of the gas is properly effected: that is, it gives three times as much light as the flame of a tallow candle will do. To show the quantity of light produced by a given quantity of coal, from late experiments which I have made with the apparatus of Mr. Winsor to ascertain the quantity of light which a given quantity of coal, either by weight or measure, is capable of affording, I have reason to state that three bushels of coal afford a quantity of light which is equal to 1470 candles at twelve to the pound, these candles burning for four hours.

Accum's photometric experiments were subjected to considerable ridicule at this hearing by Murdoch's attorney, Henry Brougham (afterwards Lord Brougham, the celebrated Chancellor). This versatile young lawyer, who was also an accomplished scientist and mathematician, made Accum the chief target of his sarcasms and handled him so severely in the cross examination that the incident became a subject of comment. Accum's reticence about divulging private technical knowledge to the rival of his client is excusable, but his objection to communicating secret knowledge at a public hearing without a fee, while perhaps intended only as a legal technicality, gave him the reputation of being sordid and mercenary.

Mr. Accum (cross-examined by Mr. Brougham).

Brougham—You stated on comparing the gas-light with the common flame of a candle you had measured the diameters and had taken equal diameters?

Accum—The whole bulk together, the whole magnitude.

B.—How did you measure it?

A.—By the shadow and with instruments.

B.—What instruments?

A.—By the photometer of Mr. Leslie and Count Rumford and instruments of my own invention.

B.—Did you use one of your own invention?

A.—I mean an opportunity of my own; a means.

B.—Is that opportunity of your own published in any book?

A.—No, it is not.

B.—Is it a secret?

A.—I do not deal in secrets; but I do not wish to communicate it.

B.—Does this opportunity of yours measure the size of the flame?

A.—It measures the size of the flame as well as the intensity.

B.—When you say that one flame is double another, do you mean to say that one is one superficial inch and the other two superficial inches?

A.—I got a tallow candle and produced a flame of a certain size and then I produced a gas flame of double that size.

B.—You say you first produced a flame of half an inch diameter and an inch long; what did you do next?

A.—The next thing was the gas flame and I produced a gas flame one inch in diameter and two inches long.

B.—Then how did you consider these two standing in relation to each other?

A.—By the common arithmetical proportions as they are usually known.

B.—What did you consider it?

A.—I considered it double the quantity and size.

B.—My idea is that it is four times.

A.—My opinion is that it is not.

B.—What is your opinion founded upon?

A.—I rest my opinion upon the facts.

B.—In what way did you measure the bulk of the light?

A.—From what passed before this Committee yesterday concerning the inquiry that has been made to estimate my practical skill with regards to the evidence I am called upon to give, I beg leave to be informed by the chairman whether I have a right to answer this question without a fee: I mean to say, whether I am obliged to inform the learned council of the practical proceedings of my profession which now form a part of my livelihood?

B.—The mode you employed in making this admeasurement you described yesterday.

A.—One of them I did, the other I find myself not inclined to state.

B.—You mean because they are secrets?

A.—Not in the least, but it is a part of my business to be paid for giving information to those who are tormented with the desire of gaining knowledge.

B.—That information given yesterday was without a fee.

A.—Certainly, but it was scanty and the other shall be paid for.

B.—Any thing further then you decline to state?

A.—I do.

The slips and evasions which Accum made in this part of his testimony were seized upon by Brougham in his concluding speech, when in referring

to the witness's method of flame measurement, he said with much irony—"I fancy the way of measuring which he here alluded to, was by those accurate 'common geometrical means' which taught him that a circle of two inches diameter was only double the size of a circle of one inch diameter. By such means he measured images so produced. Of such experiments and calculations is composed that which the courtesies of this place oblige me to call the evidence of Mr. Accum."

The experience and caution gained from this hearing apparently taught Accum a good lesson for his subsequent testimony before a Committee of the House of Lords was of a more convincing character. In 1810 Parliament finally passed a bill which permitted the incorporation of Winsor's company, and in 1812 the "Chartered Gas-Light and Coke Company" was established, Accum's name appearing as "practical chymist" upon the first board of directors. In 1813 Westminster Bridge and in 1814 the streets of Westminster were lighted with gas. The success and economy of this means of illumination having been sufficiently demonstrated, progress now became rapid and by 1815 the length of gas mains in the streets of London amounted to 15 miles. The new gas company was fortunate in securing, as its engineer, Mr. Samuel Clegg to whose inventiveness a large portion of the success was due.

Considerable prejudice was at first aroused against the introduction of gas lighting and this resulted in no small measure from the fact that Sir Humphry Davy and several other noted scientists condemned this method of illumination as unsafe. In 1814 an examining committee of the Royal Society, headed by Sir Joseph Banks, visited the gas works at Westminster and made a strong recommendation to the government that no gas holders should be permitted to exceed 6000 cubic feet in capacity. Accum, who installed a number of gas plants, quietly ignored this recommendation, for in 1815 we find him quoting the price of a gasometer to contain 10,000 cubic feet at £236, and this was less than half the size of the gas holder already in use at the Brick Lane Works (22,000 cubic feet). The alarm at the growing size of gas holders found expression in Davy's famous query—"If it were intended to take the dome of St. Paul's for a gasometer." Yet it was not 100 years before gas holders were being constructed to contain 15,000,000 cubic feet, which is several times the space roofed over by this dome.

By his efforts to quiet the prejudices of the public against gas lighting, Accum rendered the new industry as great a service as by his chemical researches. In the reports of his testimony printed by the government, in his papers—"On Illuminating Streets by Coal-Gas" in Thomson's *Annals of Philosophy* (1815) and in Ackermann's *Repository of Arts and Manufactures* (1816), and in his various books upon gas lighting we see him occupied not only as a chemist, but also as a most skilful propagandist.

In the early days of gas lighting—just as was the case thirty years ago with acetylene—there were many bunglers who considered themselves competent to install gas plants and there resulted, as a consequence, a considerable number of fires and explosions. All of this tended to retard the progress of gas lighting and Accum rendered no small service by investigating the causes of such disasters and showing that the accidents were due not to the system itself but to some error of ignorance or neglect.

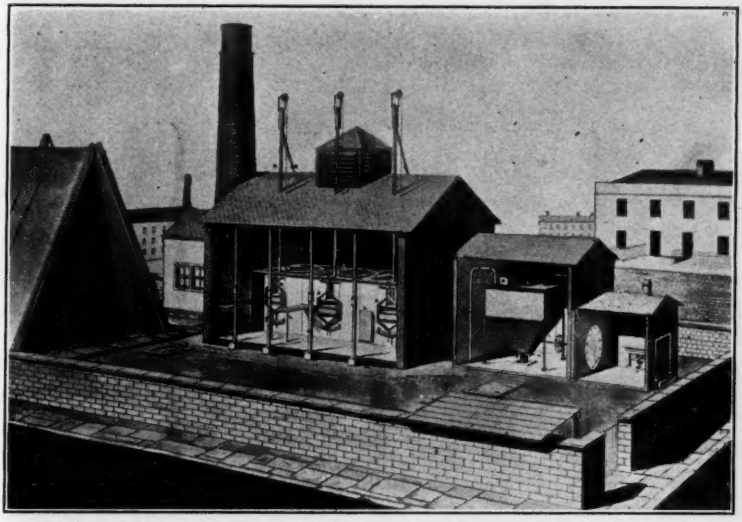

FIG. 8.—General view of gas plant for illuminating the Royal Mint. Plate in colors from Accum's description of the process of manufacturing coal gas, published at London in 1820.

The objection, made so frequently over one hundred years ago against the steam engine and other labor-saving devices, was also made against gas lighting.

On the first introduction of gas lights (writes Accum) great but happily unsuccessful endeavours were made to alarm the public mind by dismal forebodings of the destruction which would ensue to the Greenland trade, and the consequent loss of a valuable nursery of British seamen. When impartially considered it will be found that there was nothing more in this objection than the common clamour that is always set up against every new means of abridging labour, to which had the public listened, an interdict would have been laid upon the spinning and threshing machines, the steam engine and a thousand other improvements in machinery.

Such clamour scarcely ever fails to be made when the extension of machinery, the application of inanimate power, and the abridgment of labour consequent on either, is a matter proposed. We are then sure to be told that the scheme of mechanical or chemical improvement is pointed against the human species, that it tends to drive them out

of the system of beneficial employment and that, on the whole, the sum of the improvement is not only a less proportion of good to society, but a positive accession of misery to the unemployed poor.

It ought never to be forgotten, that it is to manufactories carried on by machinery, and abridgment of labour, that this country is indebted for her riches, independence, and prominent station among the nations of the world.

Authentic estimates have shewn, that the use of machinery in Great Britain is equivalent to an addition to the population of upwards of one hundred millions of adult persons.

This immense accession of power has enabled this country to withstand assaults, and to achieve objects of political ambition, that appear almost miraculous when compared with the geographical extent and numerical population of the kingdom.

With respect to what has been advanced as to the probable injury that would result from the general adoption of the gas-lights all over the country, to the Greenland trade, it may be observed that the traffic might with more propriety be called a drain than a nursery of the naval force. The nature of the Greenland service requires that the crew should consist of able bodied sailors; and being protected men, not subject to the impress law, they are rendered useless for national defence. The nursery of British seamen is the coasting trade; and as the gas-light illumination becomes extended it will increase that trade as much as it diminishes the Greenland fishery.

Even on the extreme supposition that it would annihilate the Greenland fisheries altogether, we should have no reason to regret the event. The soundest principles of political economy must condemn the practice of fitting out vessels to navigate the polar sea for oil, if we can extract a superior material for procuring light at a cheaper rate from the produce of our own soil.

The reputation of Accum as a coal-gas expert became well established throughout England. He advertised to contract "with any committee, directory, or public company for lighting with gas any town, manufactory, or building upon whatsoever scale of magnitude for an annual specific sum." Among the gas plants which he planned and operated was one for illuminating the Royal Mint, of which a diagram is given in the accompanying photograph of a colored plate from Accum's book.

The purpose of the "Chartered Gas Light and Coke Company," according to its articles of incorporation, was the very broad one of "procuring coke, oil, tar, pitch, ammoniacal liquor, essential oil, and inflammable air from coal." Accum, as chemist of the company, was occupied not only with gas production but with the yield and utilization of these numerous by-products.

The ammoniacal liquor from a ton of Newcastle coal, according to Accum, yielded from 24 to 29 lbs. of ammonium sulfate, which was either sold as such or converted into ammonium chloride by treatment with common salt. Owing to the excise laws relating to the use of common salt in England a century ago, the manufacture of ammonium chloride was largely retarded and immense quantities of the ammonium sulfate obtained from gas factory liquor was exported to the continent for conversion into sal ammoniac. This loss of an important national industry led

Accum to protest against the operation of excise taxes in the manufacture of chemicals.

Another objection which he made against this form of tax is contained in his "Process of Manufacturing Coal Gas."

> Chemical manufactories (he writes), of all others, will least bear excise, because many of them are worked according to secret processes which, if made public, must pass into other countries; and the greatest part of the profit ceases together with the export. The vexatious introduction of excise officers into manufacturing laboratories, it is evident, puts an end to all secrecy of operation. There are several chemical proc-

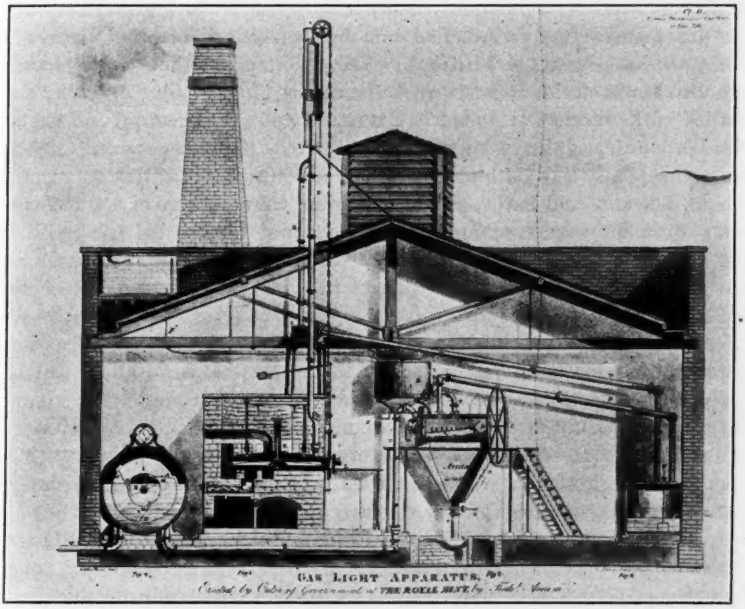

FIG. 9.—Diagram of gas light equipment erected by Accum for the Royal Mint. Frontispiece in colors from Accum's description of the process of manufacturing coal gas, published at London in 1820.

> esses which interruption will extremely injure, and others which it totally destroys and, as on the whole they in general are of a nature in which interference of others is most peculiarly vexatious, in all probability, if the excise be extended to manufactures of this nature it will eventually put a stop to most of them and greatly injure the revenue by causing thereby to cease the duties which at present arise from the exports and imports to a large amount, now depending on the chemical trade of Great Britain.

In the 15 years of Accum's connection with coal-gas technology, he saw the art expand from a small experimental undertaking to a firmly established chemical industry. In summing up his experiences and observations

upon illuminating gas manufacture in 1820, he commented thus as to the future:

> Perhaps the reader may be inclined to think, from the extraordinary height to which improvement has been carried in this art, that little or nothing more remains to be desired with regard to it. Let it be remembered, however, that the whole art is only in its infancy. There is yet a wide field for improvement in the construction of the apparatus. Ingenious men may speculate from what has been done to what remains to be effected which, no doubt, will lead to objects of the greatest utility and most extended national importance.

Accum's interests in industrial chemistry were not limited, however, to gas manufacture for we find him busily engaged in other lines. In 1819 the inhabitants of Thetford, wishing to improve the welfare of their ancient town, decided to advertise the merits of their mineral spring and called in the services of Accum. His report upon the chemical and medicinal properties of the spring was so satisfactory that he was authorized to draw up plans for a bathing establishment. Under his direction a pump room, hot and cold baths, and all the other conveniences of a water-cure establishment were erected and the place was opened for use in 1820. In connection with this undertaking, Accum published in 1819 a "Guide to the Chalybeate Spring of Thetford" for the convenience of the public.

Accum in the course of his work as a technical chemist devised various preparations for industrial purposes. The best known of these was his compound for welding iron which consisted of a mixture containing 1 ounce of flowers of sulfur, 2 ounces of sal ammoniac, and 16 ounces of iron dust. In welding, 1 part of the above mixture is ground up in a mortar with 20 parts of fine iron filings and water added to the necessary consistency. The pasty mass is then quickly smeared over the broken joint. The heat produced in the compound by the formation of iron sulfide is sufficient to weld the broken surfaces of metal. Accum's welding compound, which was the prototype of similar modern preparations, had an extensive use in its day. It had the objection of giving off suffocating gases and fatalities resulted from its employment in confined spaces.[1]

The services of Accum, as a chemical expert, were always in great demand at hearings and trials. His testimony before Parliament in connection with the Gas-Lights Bill has already been referred to. Another famous case with which he was connected was the action brought by Severn, King, and Co., sugar refiners, against the Imperial Insurance Co. for the payment of insurance on their White Chapel Refinery. Probably few trials have ever had such an array of celebrated chemical talent. On the side of the refiners we find such experts as Accum, Brande, Davy, Dalton, Henry, Parkes, Pearson, and Thomson, while on the side of the insurance company

[1] Schweiger's *Journal für Chemie und Physik*, **41**, 384 (1824).

we note such witnesses as Aikin, Bostock, Faraday, Garden (Accum's former partner), Tilloch, and Wilkinson.

The cause of this lawsuit was most interesting. Severn, King, and Co. had insured their refinery with the Imperial Insurance Co. for £70,000. In August, 1819, they introduced a new process for boiling sugar by means of heated oil. The apparatus, which was patented by Wilson, consisted simply of a large boiler, in which whale oil was heated to between 350° and 400°F. and from which it was then pumped through the coils of the sugar pans back again to the boiler for reheating. The invention diminished the danger of caramelization, incident to the old method of boiling the sugar over the direct fire, and at the same time was considered to be more economical and less dangerous. The new apparatus worked smoothly and profitably for three months when a fire broke out and practically destroyed the refinery. The insurance company refused to pay the claims for insurance on the ground that the fire originated from the use of oil in a process which was unsafe and which had been introduced without their consent.

The question about which the battle of chemical experts waged was whether the method of oil heating was more or less dangerous than the boiling of sugar solutions over the open fire. The experts for the refiners testified that the new process was less dangerous. Accum stated that if the fire resulted from an explosion of oil gas in the fill house, as had been asserted, the noise of the explosion would have been heard all over London. The experts for the insurance company testified that the oil process was more hazardous and laid special stress upon the claim that whale oil through the continued process of reheating underwent decomposition with a consequent increase in the danger of inflammability.

The testimony of Faraday, who was recalled to the stand several times during the trial, did not make an altogether favorable impression upon the jury. Faraday cited experiments to prove the danger of increased inflammability but it was brought out on cross-examination that he had used an unprotected boiler for heating his oil instead of a protected boiler as was used in the refinery. This cross-examination and the opposing evidence of his chemical colleagues caused Faraday so much chagrin that he refused ever again to appear as an expert witness in a lawsuit.

After listening to a large amount of conflicting testimony, which brought forth severe strictures from the judge, the jury rendered a verdict in favor of the refiners.

Chapter IV

Author and Pioneer Crusader against Food Adulteration

Leaving now the activities of Accum as teacher, tradesman, analyst, and technical chemist, it remains to review briefly his career as an author.

It is in the latter capacity that he was longest remembered and that he exerted his greatest influence. His books were translated into many languages and went through numerous editions, although, with the lack of international copyrights one hundred years ago, the financial rewards of the author were never commensurate with the sale. The works of Accum were all written in the midst of his other numerous activities and they give a good illustration of the unremitting energy of the man. It is perhaps needless to state that these books, of which there are some twentv, are not all of equal merit; some of them bear the evidences of haste and can be called only compilations, or "scissors-and-paste" publications, prepared, after the manner of Nicholson and other authors of that time, from early editions of his own works or from the writings of others. No author understood better than Accum the practical appeal of chemistry to the popular mind and his books acted towards this appeal both as a stimulus and a response.

In 1803 Accum published his first book, entitled a "System of Theoretical and Practical Chemistry," in two volumes. The work, which was written as a text-book for students, is dedicated to the managers of the Royal Institution of which he was then chemical operator. As one of the earliest English chemistries to be based upon the new principles of Lavoisier, this first effort of Accum has a special interest. The tribute which he pays in the beginning to the great French chemist is among the best which has been written.

This first book, being the work of an untried writer, was published by Accum himself. The author's efforts were supported by five hundred subscribers, among whom were such influential men as the Duke of Sussex, the Marquis of Lansdown, Admiral Nelson, Viscount Palmerston, Lord Camelford, Sir Joseph Banks, and Sir William Hamilton. Among other supporters were Accum's patron, Dr. Anthony Carlisle, various relatives and friends in his native city of Bückeburg and former associates in the Brande Pharmacy of Hanover. The first impression which the published list of subscribers makes upon the reader is the almost complete absence of chemists. Physicians and clergymen are well represented, likewise officers in the army and navy, but of contemporary British and European chemists there is not a name of distinction although subscriptions came from nearly every city of Great Britain and from Paris, Berlin, St. Petersburgh, Lisbon, and other places on the continent. The one exception to this apparent display of professional indifference is the name of Dr. James Woodhouse, Professor of Chemistry at the University of Pennsylvania in Philadelphia, who was the only subscriber in America. But it was to the unprofessional public, among whom he sought to popularize chemistry, that Accum made his chief appeal and it was only natural that his "System of Chemistry" should have found its main support among lay readers and students.

Besides being one of the few chemical text-books published by advanced subscription, the first edition of Accum's chemistry has an additional bibliographic interest in that it was printed upon paper manufactured from straw. The pages of a copy in the author's possession, although coarse and yellow, are still in excellent condition.

Accum's "System of Chemistry," as compared with previous books, in English, upon the subject, shows several points of departure. The earlier chemistries of Black and Priestley and the translations of Bergman and Lavoisier consisted mostly of personal researches and were not written with the purpose of introducing beginners to the science. Accum's treatise, on the other hand, as explicitly stated in his preface, was "composed for the instruction of such as are actually unacquainted with chemical science." The basis of the author's method consists of a carefully graduated series of experiments.

> I have endeavored (he writes) experimentally to unfold all the fundamental truths of the science. I proceed from first notions step by step; from generals to particulars; from premises to conclusions; deducing causes from their effects and effects from their causes in order to maintain a systematic connection between the several parts of the whole, and to recall to the memory all the changes which bodies are susceptible of in their mutual actions.
>
> I am persuaded this cannot be better done than by determining their properties by experiments under different circumstances. Hence the same facts are exhibited under various forms and relations, in order to oblige the mind to reconsider the same phenomena in different lights.
>
> I am fully convinced that chemistry cannot be learned without actually applying to the operative part of the science. It is obvious that success must greatly depend on minute and clear instructions: this method of teaching cannot therefore be deemed trifling. I have indeed written for beginners: but accuracy and precision are so far from being faults, that they are more acceptable even to proficients, than that loose descriptive method which leaves the whole detail of quantities, order, and operation, to be supplied by the trials of the reader himself.

These quotations from the author's preface not only announce a new departure in the writing of chemical text-books but they serve also to illustrate the perfect mastery of English which Accum had acquired during the ten years of his residence in London. All of Accum's books are excellently written; in style, clarity, and correctness of language they are models of scientific expression.

A second distinguishing feature of Accum's "System of Chemistry" is the attention which he gives to the chemistry of the arts and of the simple phenomena of daily life. His explanation of such operations as the fermenting of vinegar, the manufacture of soap, the silvering of mirrors, etc., although most deficient in the light of present knowledge, were, nevertheless, valuable in that they aroused in the student a sense of the direct personal significance of chemistry and of its practical importance as applied to manufactures and the needs of human existence.

A second edition of Accum's "System of Chemistry" appeared in 1807 and a reprint of this was published in Philadelphia in 1808. The work received a large number of favorable notices but of these only the following remarks of Dr. Thomas Cooper in 1813, in his preface to the second American edition of Accum's book, will be quoted:

> Upon the whole, it seems to me that Accum's method of treating the subjects of chemistry is more satisfactory to students than any other of the elementary treatises that have appeared; and it has the advantage of being neither too voluminous for a course, nor so brief as to be obscure.

This also was the opinion of Dr. Thomas Ewell of Virginia who followed closely the practical method of Accum in his book "Plain Discoveries on

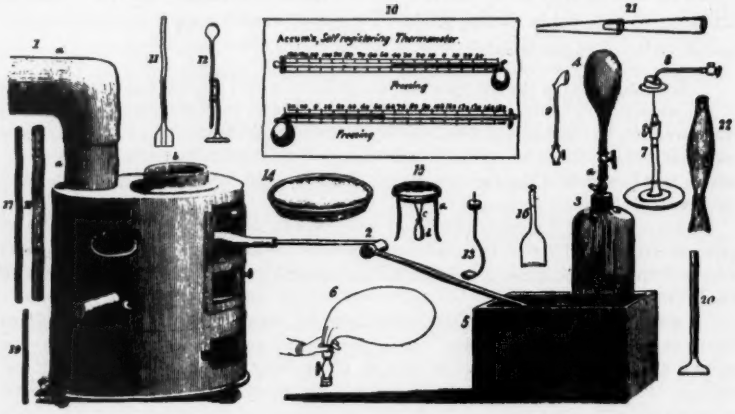

FIG. 10—Illustrations of Apparatus from Accum's "System of Chemistry," 2nd Edition.

the Laws or Properties of Matter," containing the elements or principles of modern chemistry, with more particular details of those practical facts of the science most interesting to mankind and connected with domestic affairs, published at New York in 1806. Dr. Ewell writes in the preface of this once very popular American treatise:

> I availed myself of the writings of the best chemists. When conscious of an inability to improve I imitated their manner of stating facts. To the systems of chemistry by Thompson, Chaptal, Murray, and particularly that by Mr. Accum, I am indebted. The copious extracts from this last author will much increase the value of this work.

In 1804 Accum brought out his second work, "A Practical Essay on the Analysis of Minerals," in which he gives a resumé of his extensive experience in this field. After a short description of the apparatus and general technique of mineral analysis the author describes briefly in the first part of his book the current methods for analyzing the ores of twenty-

two metals. The second part of the treatise is devoted to the analysis of the so-called earths, such as the compounds of silica, alumina, lime, magnesia, barytes, strontia, yttria, etc., and to the chemical examination of soils. In the third part of the book the analysis of mineral salts is discussed and in the fourth part the examination of inflammable fossils or coal. An American reprint of this book was published in Philadelphia in 1809.

The "Analysis of Minerals" was rewritten in 1808 and enlarged to two volumes with the title, "A Manual of Analytical Mineralogy." In its day it was the best work in English upon the subject and passed through several editions, but with the rapid improvement in analytical methods was finally superseded by other books.

In 1809 Accum published a small syllabus entitled "An Analysis of a Course of Lectures on Mineralogy" which was enlarged and reprinted the following year as "A Manual of a Course of Lectures on Experimental Chemistry and Mineralogy." These works were intended as guides for the use of his students.

Accum's love for mineralogy and the growing popular interest in this department of natural science led him in 1813 to publish his "Elements of Crystallography" which was the first book upon the subject to appear in English. The work is based upon the principles of Haüy and is illustrated with numerous diagrams and plates of crystals. The volume is dedicated to Earl Percy, Count Meinhovel, Sir John Warren and Sir John Sebright who were among those to whom Accum delivered lectures upon the subject. It was to exemplify the contents of this book that Accum manufactured the crystal models to which reference has been made.

Accum's "Descriptive Catalogue of the Apparatus and Instruments Employed in Experimental and Operative Chemistry, in Analytical Chemistry, and in the Pursuits of the Recent Discoveries of Electro-Chemical Science," was published at London in 1812. This work of 60 pages, illustrated with sixteen copper plates, was a descriptive trade catalog of the apparatus, chemicals, etc., that were sold by the firm of Accum and Garden. There are described and listed 328 pieces of apparatus and 340 chemicals.

In 1815 Accum published his famous "Practical Treatise on Gas-Light;" exhibiting a summary description of the apparatus and machinery best calculated for illuminating streets, houses, and manufactories, with carburetted hydrogen, or coal-gas; with remarks on the utility, safety, and general nature of this new branch of civil economy. This book became a classic for it is the first work in any language that deals with the subject of gas illumination; it is splendidly illustrated with colored plates printed at the art establishment of Rudolph Ackermann, who was himself one of

the pioneers in gas lighting, having equipped his residence and place of business in the Strand with a gas plant as early as 1811.

Accum's principal purpose in writing his "Treatise on Gas-Light" was to rescue the art of illumination with coal gas from the misconceptions and misrepresentations into which it had been thrown by ignorant and prejudiced opponents. After an introductory essay on the importance of the artificial production of light upon human morals and welfare the author gives an historical sketch of gas-light illumination which is followed with a general description of the theory, economy, apparatus and methods of producing coal-gas. Accum includes in his discussion not only a summary of his own extensive experiments and observations but a general review of all that had been accomplished in gas manufacture up to 1815. The lithographs of beautiful gas lamps, chandeliers and candelabra contained in this treatise show what rapid advancement this new method of illumination had made since its introduction in London twelve years before.

The "Treatise on Gas-Light" passed through four English editions in three years. In 1816 a German translation by A. W. Lampadius, "Praktische Abhandlung über die Gaserleuchtung," was published in Berlin. A second German edition was printed at Weimar in 1819, to which a supplement, "Methode das Gaslicht tragbar und dadurch brauchbar zu machen," by D. Gordon was published in 1820. A French translation, "Traité pratique de l'eclairage par le gaz inflammable," was published, with a preface and additions by F. A. Winsor, in Paris in 1816. The book was also translated into Italian.

Owing to the new developments which were taking place in gas lights, Accum entirely rewrote his "Treatise on Gas-Light" in 1819 and published it under the title of a "Description of the Process of Manufacturing Coal-Gas, for the Lighting of Streets, Houses, and Public Buildings, with Elevations, Sections, and Plans of the Most Improved Sorts of Apparatus Now Employed at the Gas Works in London and the Principal Provincial Towns of Great Britain." A second edition of this was printed in 1820.

Accum's two works upon coal-gas are written in his customary excellent English style. Practical descriptions of methods are interspersed with occasional observations of a philosophic nature which reveal the mature judgment of a scholarly mind.

In 1816 Accum published his "Practical Essay on Chemical Reagents or Tests Illustrated by a Series of Experiments" which proved to be a very popular work. An enlarged second edition appeared in 1818 under the title "Practical Treatise on the Use and Application of Chemical Tests with Concise Directions for Analyzing Metallic Ores, Metals, Soils, Manures and Mineral Waters." A third edition was brought out in 1828 by J. Maugham, six years after Accum's return to Germany. An American edition of the work was published in Philadelphia in 1817. A translation

ELEMENTS

OF

CRYSTALLOGRAPHY,

AFTER THE METHOD OF HAÜY;

WITH, OR WITHOUT,

Series of Geometrical Models,

BOTH

SOLID AND DISSECTED;

EXHIBITING THE FORMS OF CRYSTALS, THEIR GEOMETRICAL STRUCTURE, DISSECTIONS, AND GENERAL LAWS,

ACCORDING TO WHICH THE

IMMENSE VARIETY OF ACTUALLY EXISTING CRYSTALS ARE PRODUCED.

By FREDRICK ACCUM,

OPERATIVE CHEMIST,

LECTURER ON PRACTICAL CHEMISTRY, ON MINERALOGY, AND ON CHEMISTRY APPLIED TO THE ARTS AND MANUFACTURES; MEMBER OF THE ROYAL IRISH ACADEMY, FELLOW OF THE LINNEAN SOCIETY, &c.

WITH COPPER-PLATES.

London:

PRINTED FOR LONGMAN, HURST, REES, ORME, AND BROWN, PATERNOSTER-ROW.

1813.

Fig. 11.—Title page of Accum's "Elements of Crystallography;" this was the first book upon the subject in the English language. The crystal models designed by Accum to accompany this book were also the first to be sold to the English-speaking public.

into French, "Traité' pratique sur l'usage et le mode d'application des réactifs chimiques," by Riffault was published at Paris in 1819 and an Italian translation of the second English edition, "Trattato practico per l'uso ed applicazione de'reagenti chimici," by G. Pozzi was issued in two volumes at Milan in 1819.

In 1817 Accum brought out his well-known work entitled "Chemical Amusements, a Series of Curious and Instructive Experiments in Chemistry Which Are Easily Performed and Unattended by Danger." This book was written in the author's happiest vein and was greatly appreciated by amateur experimenters. The first edition was exhausted in two months and the demand increased so rapidly that the second edition was sold out within a week. A third edition appeared in 1818 and a revised fourth edition in 1819. The work had a long popularity both in England and America. The second American edition was prepared, with additions, by Dr. Thomas Cooper from the third English edition and published in Philadelphia in 1818.

In his "Chemical Amusements" Accum describes over one hundred and fifty simple experiments, a rationale, or theoretical explanation, being attached to each operation. The experiments of this book are still instructive and while the explanations are out of date they are interesting for the light which they throw upon the chemical theories that prevailed one hundred years ago. The following explanation, for example, of the soluble action of a mixture of nitric and hydrochloric acids upon gold brings up an issue that perplexed the minds of chemists for nearly a generation.

"During the mixture of the acids, a mutual chemical action takes place; part of the nitric acid is decomposed, one portion of its oxygen is surrendered to a portion of the muriatic acid and another part of its oxygen combines with the gold and converts it into an oxide of gold; and this oxide is dissolved in the remaining portion of the muriatic acid, with which it forms muriate of gold. The portion of nitrous gas or red vapour, which is produced by virtue of a part of the nitric acid losing oxygen, becomes dissolved in the fluid and gives to it the orange color; whilst the oxymuriatic acid formed, flies off in the state of gas, and occasions the air bubbles in the mixture."

This was written in 1817. Berzelius believed until 1820 that the anhydride of muriatic acid contained oxygen and that this anhydride upon further oxidation yielded oxymuriatic acid gas or chlorine.

Accum's "Chemical Amusements" underwent translation into many European languages. A German translation, "Chemische Unterhaltungen," was issued in Copenhagen in 1819. Another German translation of the third English edition called "Chemische Belustigung" was printed in Nuremberg in 1824. The work was also very popular in France where it

A

PRACTICAL TREATISE

ON

GAS-LIGHT;

EXHIBITING

A SUMMARY DESCRIPTION

OF THE

APPARATUS AND MACHINERY

BEST CALCULATED FOR

ILLUMINATING

STREETS, HOUSES, AND MANUFACTORIES,

WITH

CARBURETTED HYDROGEN, OR COAL-GAS;

WITH REMARKS

ON THE

UTILITY, SAFETY, AND GENERAL NATURE OF THIS NEW BRANCH OF CIVIL ECONOMY.

By FREDRICK ACCUM,

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WITH SEVEN COLOURED PLATES.

London:

PRINTED BY G. HAYDEN, BRYDGES-STREET, COVENT GARDEN;

FOR R. ACKERMANN, 101, STRAND;

LONGMAN, HURST, REES, ORME, AND BROWN; AND SHERWOOD, NEELY, AND JONES, PATERNOSTER ROW; AND J. HATCHARD, PICCADILLY.

Price—Twelve Shillings in Boards.

1815.

Fig. 12.—Title page of Accum's "Practical Treatise on Gas-Light." This was the first book ever published upon the subject.

appeared in 1827 under the title "Manual de Chimie Amusante; ou nouvelles recreations chimiques, contenant une suite d'experiences d'une execution facile et sans danger, ainsi qu'un grand nombre de faits curieux et instructifs," translated by V. Riffault and afterwards re-edited by A. D. Vergnaud for the Manuels-Roret series. A sixth enlarged edition of this French translation was published in Paris as late as 1854. The book also found many friends in Italy. A two-volume translation called "Divertimento chimico contenente esperienze curiose" was published at Milan in 1820; a second enlarged translation by Pozzi entitled "La Chimica dilettevole o serie di sperienze curiose e instruttive di chimica chi si esequiscono con facilità e sicurezza" was printed in Milan as late as 1854.

In 1821 Accum's "Dictionary of the Apparatus and Instruments Employed in Operative and Experimental Chemistry" was brought out. This work dealt with a subject in which the author's long experience as demonstrator, manufacturer, and analyst gave him a most intimate knowledge and for this particular phase of chemistry the book was long authoritative. It contains descriptions and illustrations of over two hundred kinds of chemical apparatus, which for convenience of reference are arranged in alphabetical order. The work was reprinted in 1824, with omission of Accum's name, under the title "Explanatory Dictionary of the Apparatus and Instruments Employed in the Various Operations of Philosophical and Experimental Chemistry by a Practical Chemist."

In the later years of his London life, Accum became intensely interested in the chemistry of foods and there was a rapid succession of books from his pen upon this subject. One of his first works upon foods was the well known "Treatise on the Art of Brewing," published in 1820, which described the brewing of porter, stout, ale, beer, and other malt liquors as practiced in London at that period. The book for its time is exceedingly complete and must always be consulted by those who are investigating the bibliography of the subject. In addition to its technical information the work gives a valuable digest of the statutory laws which regulated the practice of brewing a century ago.

Accum's "Treatise on Brewing" passed through several English editions. A German edition, "Abhandlung über die Kunst zu brauen," translated from the English by Accum's niece, Fredrica Strack of Bückeberg, was published in 1821, and a French translation by Riffault, "Manual théorique et pratique du brasseur," appeared in Paris in 1825. An enlargement of this French translation, entitled "Nouveau Manuel Complet du brasseur, ou l'art de faire toutes sortes de biere," was edited by A. D. Vergnaud for the Manuels-Roret series in 1838. The book was reprinted in Paris as late as 1853.

Another very popular book upon beverages was Accum's "Treatise on the Art of Making Wine from Native Fruits," which was published first

in 1820 and passed through many editions. In this work the author, after an historical sketch of the art of wine-making and a general description of the processes of fermenting, racking, and clarification, describes the manufacture of home-made wines from grapes, currants, cherries, plums, berries, peaches, and other fruits. The good staying quality of Accum's books is illustrated by the fact that his treatise on wine was reprinted in London as late as 1860 and that a French translation, "Nouveau Manuel complet de la Fabrication des Vins de Fruits," first published in the Manuels-Roret series in 1827, was re-edited in Paris as late as 1851. Even within the last few years, owing to the impetus given to home-wine manufacture as a result of restrictions in the sale of alcoholic beverages, there has been a renewed demand in public libraries and second-hand book stores for Accum's treatise on making wine from fruits.

Accum's "Treatise on the Art of Making Good and Wholesome Bread" was published in 1821. The book describes the chemical composition and nutritive value of the different kinds of bread prepared from wheat, oats, rye, barley, and other starch grains and of the various substitutes used for bread. Although the contents are now mostly obsolete this treatise on breadmaking still contains material that is of interest to the food technologist.

In 1821 Accum completed his well-known "Culinary Chemistry," which was published by Ackermann under circumstances to be mentioned later. In this book the scientific principles of cookery are described and practical instructions are given for preparing pickles, vinegar, preserves, jellies, marmalades, and various other substances employed in domestic economy. In his characteristic way the author develops the idea that the culinary processes of roasting, boiling, baking, stewing, frying, broiling, and preserving are all chemical processes and that the kitchen is simply a chemical laboratory, "the boilers, stew-pans, and cradle-spit of the cook, corresponding to the digestors, the evaporating basins, and the crucibles of the chemist." Accum points out that the improper cooking of food is a frequent cause of disease and as an illustration quotes the recipe of certain cookbooks of the day to "boil greens with half-pence or verdigrise, in order to improve their color."

The best known of Accum's books upon foods, and in many respects the most widely celebrated of all his publications, was his "Treatise on the Adulterations of Food and Culinary Poisons, Exhibiting the Fraudulent Sophistications of Bread, Beer, Wine, Spirituous Liquors, Tea, Coffee, Cream, Confectionery, Vinegar, Mustard, Pepper, Cheese, Olive Oil, Pickles, and Other Articles Employed in Domestic Economy, and Methods of Detecting Them." The first edition of this work appeared in January, 1820; several of its chapters were also printed in serial form in Ackermann's "Repository of Arts and Manufactures." This book is also a

classic as it represents the first serious effort to cope with the difficult problems of food adulteration. As early as 1798, Accum had called the attention of the English public to the prevalence of adulteration, and since that time his long experience as analyst and student of food technology had given him a wider and more intimate knowledge of the subject than was possessed by any chemist of the time.

The exposure of practices, which this book of Accum's contains, caused a vast amount of comment and the feelings which were aroused are reflected

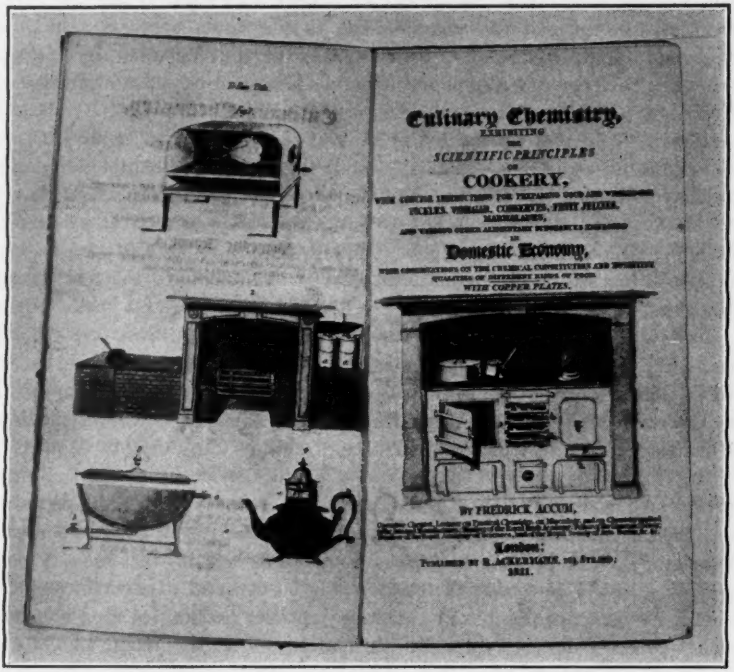


FIG. 13.—Frontispiece and title page of Accum's "Culinary Chemistry." This was the last book which Accum wrote during his residence in England.

in the reviews which appeared in various periodicals for the year 1820. The varied impressions which this pioneer work created are worth reproducing; the facetious, ironical, and angry remarks of a much abused public of a century ago have their counterpart in the more recent developments of modern times. The general make-up, character, and contents of Accum's "Treatise on the Adulterations of Food"—in all probability the most extensively reviewed book upon chemistry ever written—are described in the following extracts from contemporary journals.

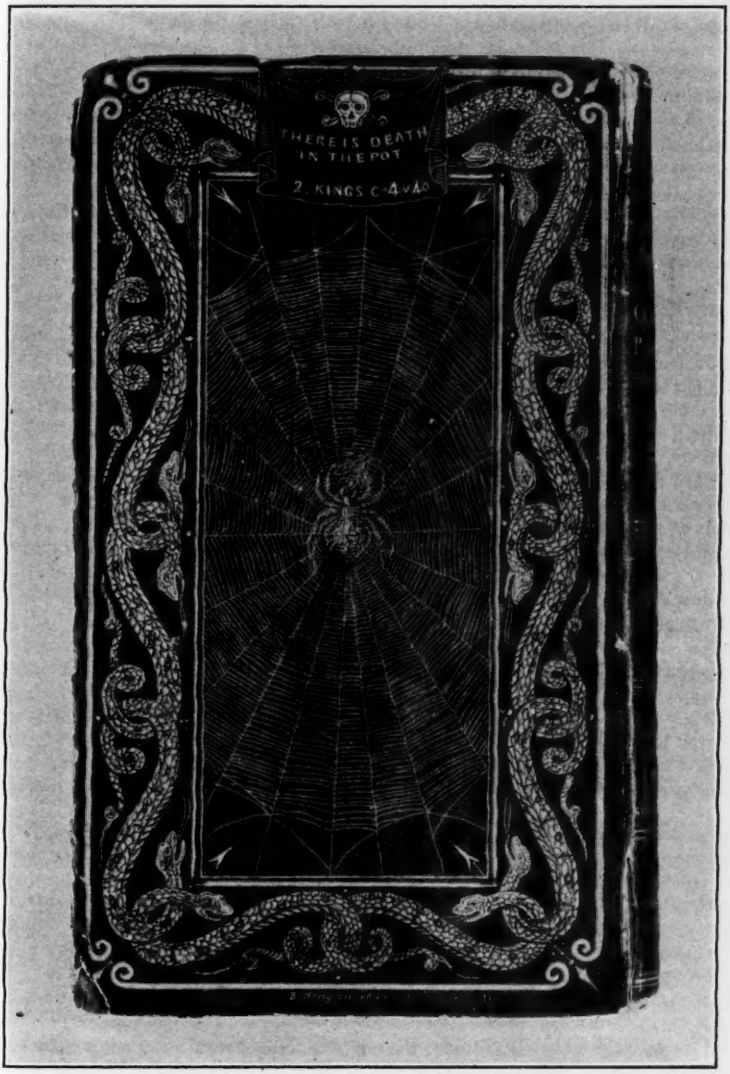


FIG. 14.—Design upon cover of Accum's "Treatise on Adulteration of Food."

Mr. Accum (says the *British Review*) seems determined that even the outside of his book shall awaken our fears. The cover of our copy bears a death's head emblazoned upon a pall and, underneath, the motto "there is death in the pot." The pall is supported by the point of a dart. Four other darts support the four corners of the device. Twelve serpents, with forked tongues and tails entwined, form a terrific wreath around; while the middle is occupied with a large cobweb, delineated with much attention to detail, in the center of which a spider, full as large as a moderate sized hazel nut, and so frightful that more than one young lady of our acquaintance would think it necessary to scream at the sight of it, holds in its envenomed fangs an ill-fated fly, which is sinking under the loss of blood and buzzing in the agonies of death.

We are by no means desirous to raise or maintain a popular clamour; but Mr. Accum certainly advances some weighty charges and his work comes with an advantage in bearing a name not unknown to the scientific world.

Blackwood's Edinburgh Magazine remarks, in a very humorous vein:

Mr. Accum's work is evidently written in the same spirit of dark and melancholy anticipation which pervades Dr. Robinson's celebrated "Proofs of a Conspiracy, etc. against all the crowned heads of Europe." The conspiracy disclosed by Mr. Accum is certainly of a still more dreadful nature and is even more widely ramified than that which excited so much horror in the worthy professor. It is a conspiracy of brewers, bakers, grocers, wine merchants, confectioners, apothecaries, and cooks, against the lives of all and every one of his majesty's liege subjects. It is easy to see that Mr. Accum's nerves are considerably agitated, that "Sad forebodings shake him as he writes." Not only at the festive board is he haunted by chimeras dire of danger—not only does he tremble over the flesh-pot; but even in his chintz nightgown, and red morcoco slippers, he is not secure. An imaginary sexton is continually jogging his elbow as he writes; a death's head and cross bones rise on his library table: and at the end of his sofa he beholds a visionary tombstone of the best granite—

ON WHICH ARE INSCRIBED THE DREADFUL WORDS—

Hic Jacet

FREDRICK ACCUM,
Operative Chemist,
Old Compton Street,
SOHO.

Melancholy as the details are, there is something almost ludicrous, we think, in the very extent to which the deceptions are carried. So inextricably are we all immersed in this mighty labyrinth of fraud that even the vendors of poison themselves are forced, by a sort of retributive justice, to swallow it in their turn. Thus the apothecary, who sells the poisonous ingredients to the brewer, chuckles over his roguery and swallows his own drugs in his daily copious exhibitions of brown stout. The brewer, in his turn,

is poisoned by the baker, the wine-merchant, and the grocer. And, whenever the baker's stomach fails him, he meets his *coup de grace* in the adulterated drugs of his friend the apothecary, whose health he has been gradually contributing to undermine, by feeding him every morning on chalk and alum, in the shape of hot rolls.

The *Edinburgh Review* makes its comments in a more serious tone:

Of these various frauds so ably exposed in Mr. Accum's work, and which are so much the more dangerous, as they are committed under the disguise of an honourable trade, it is impossible to speak in terms of too strong reprobation; and in the first impulse of our indignation, we were inclined to avenge such iniquitous practices by some signal punishment. We naturally reflect that such offenses, in whatever light they are viewed, are of a far deeper dye than many of those for which our sanguinary code awards the penalty of death—and we wonder that the punishment hitherto inflicted has been limited to a fine. If we turn our view, however, from the moral turpitude of the act, to a calm consideration of that important question, namely—What is the most effectual method of protecting the community from those frauds?—we will then see strong reasons for preferring the lighter punishment. We do not find from experience that offences are prevented by severe punishments. On the contrary, the crime of forgery, under the most unrelenting execution of the severe law against it, has grown more frequent. As those, therefore, by whom the offence of adulterating articles of provision is committed, are generally creditable and wealthy individuals, the infliction of a heavy fine, accompanied by public disgrace, seems a very suitable punishment: and if it be duly and reasonably applied, there is little doubt that it will be found effectual to check, and finally to root out, those disgraceful frauds.

The *Literary Gazette*, in its summary of the contents of the book, makes the following reflections:

It is so horribly pleasant to reflect how we are in this way be-swindled, betrayed, bedrugged, and be-devilled, that we are almost angry with Mr. Accum for the great service he has done the community by opening our eyes, at the risk of shutting our mouths forever.

His account of water is so fearful, that we see there is no wisdom in the well; and if we then fly to wine, we find from his analysis, that there is no truth in that liquid; bread turns out to be a crutch to help us onward to the grave, instead of the staff of life; in porter there is no support, in cordials no consolation; in almost every thing poison and in scarcely any medicine cure.

The work contains a great many excellent observations on the various sorts of water, and the modes of conveying and preserving them for use: it appears generally that leaden pipes and cisterns, and copper vessels are highly dangerous.

Good heavens! we think we hear it exclaimed, is there no end to these infamous doings? Does nothing pure or unpoisoned come to our tables, except butcher's meat which has been rendered far less nutritive than formerly, by new methods of feeding? Why, we must answer, hardly anything: for our author proceeds to shew that cheese (Gloucester he mentions) has been contaminated with red lead, a deadly poison, mixed with the colouring anotto, when that article was scarce: that pepper is adulterated with factitious pepper-corns "made up of oil-cakes (the residue of lint seed, from which the oil has been pressed), common clay, and a portion of Cayenne pepper, formed in a mass, and granulated by being first pressed through a sieve, and then rolled in a cask," and further, that "ground pepper is very often sophisticated by adding to a portion of genuine pepper, a quantity of pepper dust, or the sweepings from the pepper warehouses, mixed with a little Cayenne pepper. The sweepings are known, and purchased in the

market, under the name of P. D. signifying pepper dust. An inferior sort of this vile refuse, or the sweepings of P. D. is distinguished among vendors by the abbreviation D. P. D. denoting dust (dirt) of pepper dust."

As we read on, we learn the method of manufacturing adulterated vinegar, adulterated red cream, adulterated lozenges, adulterated mustard, adulterated lemon acid, poisonous Cayenne, poisonous pickles, poisonous confectionery, poisonous catsup, poisonous custards, poisonous anchovy sauce, poisonous olive oil, poisonous soda water; and, if not done to our hands, of rendering poisonous all sorts of food by the use of copper and leaden vessels. Suffice it to record that our pickles are made green by copper; our vinegar rendered sharp by sulphuric acid; our cream composed of rice powder or arrow root in bad milk; our comfits mixed of sugar, starch, and clay, and coloured with preparations of copper and lead; our catsup often formed of the dregs of distilled vinegar with a decoction of the outer green husk of the walnut, and seasoned with all-spice, Cayenne, pimento, onions, and common salt—or, if founded on mushrooms, done with those in a putrefactive state remaining unsold at market; our mustard a compound of mustard, wheaten flour, Cayenne, bay salt, radish seed, turmeric, and pease flour; and our citric acid, our lemonade, and our punch, to refresh or to exhilerate, usually cheap tartareous acid modified for the occasion.

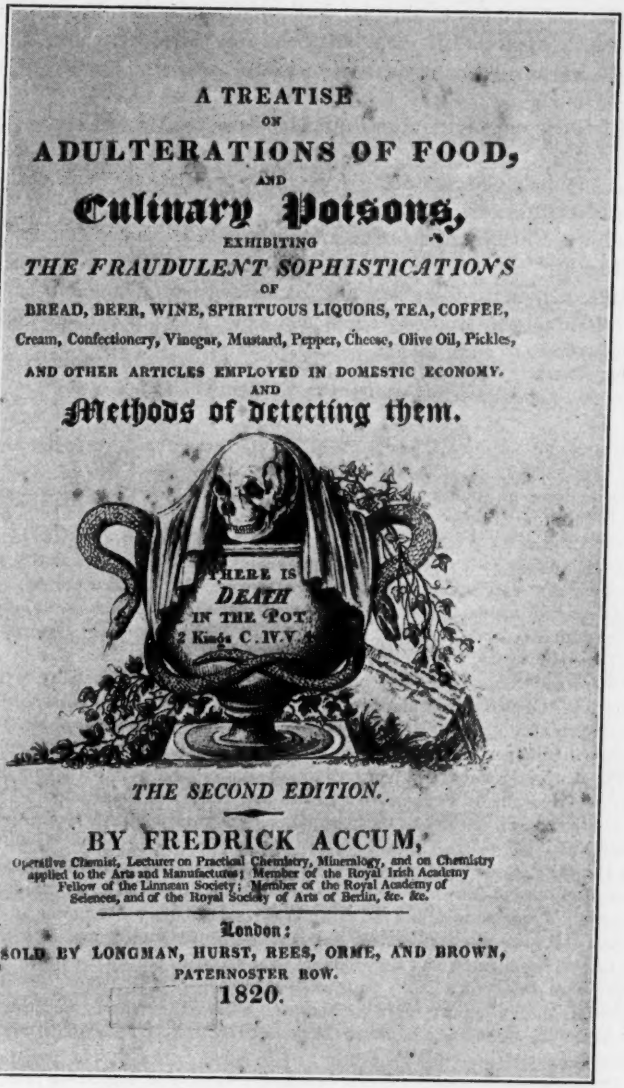
Against all these, and many other impositions, Mr. Accum furnishes us with easy and certain tests: his work, besides, contains many curious documents and useful recipes; and it is replete with intelligence, and often guides to the right while it exposes the wrong.

Accum's "Treatise on Adulterations of Food" also attracted considerable notice in the United States. The *Analectic Magazine* of Philadelphia, in reviewing the American edition of the book, in its issue for August, 1920, republished the editorial remarks of *Blackwood's Edinburgh Magazine*, to which it added the following somewhat singular comment:

This little work may, in London, be very much useful and wherever meat and bread are eaten, and wine is drunk, or physic taken must be interesting. We cannot help fearing, however, that the distinguished chemist has been laboring unwittingly in aid of fraud rather than for its detection. For one reader that is taught how to avoid adulterated food, ten will have occasion to regret that Mr. Accum has furnished the dishonest vendors with so complete a manual and guide in the manufacture of the most cunningly devised poison. It is, however, whether fortunately or not, presented to the American public. And we consult our own ease and the amusement of our readers at the same time in presenting them with the remarks and analysis made by the editors of *Blackwood's Edinburgh Magazine*, instead of any detailed observations of our own.

In his crusade against food adulteration, Accum went much further in his book than merely to describe frauds and indicate methods for their detection; he published in addition the names of individuals who had been guilty of the practice. "Mr. Accum," says one review of the day, "very properly gives us a list of those miscreants who have been convicted of adulterating their porter with poisonous ingredients, and want of room alone prevents us from damning them to everlasting fame, by inserting their names in the imperishable pages of this miscellany."

The first thousand copies of Accum's "Treatise on Adulterations of Food" were sold out within a month, when a second edition was published. There


A TREATISE
ON
ADULTERATIONS OF FOOD,
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THE FRAUDULENT SOPHISTICATIONS
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BREAD, BEER, WINE, SPIRITUOUS LIQUORS, TEA, COFFEE,
Cream, Confectionery, Vinegar, Mustard, Pepper, Cheese, Olive Oil, Pickles,
AND OTHER ARTICLES EMPLOYED IN DOMESTIC ECONOMY.
AND
Methods of detecting them.
THERE IS
DEATH
IN THE POT.
2 Kings C. IV. V.
THE SECOND EDITION.
BY FREDRICK ACCUM,
Operative Chemist, Lecturer on Practical Chemistry, Mineralogy, and on Chemistry applied to the Arts and Manufactures; Member of the Royal Irish Academy Fellow of the Linnean Society; Member of the Royal Academy of Sciences, and of the Royal Society of Arts of Berlin, &c. &c.
London:
SOLD BY LONGMAN, HURST, REES, ORME, AND BROWN,
PATERNOSTER ROW.
1820.

FIG. 15.—Title page of Accum's "Treatise on Adulterations of Food." This work, which passed through many editions in England, America, and various European countries, marked the beginning of the modern pure food movement.

was a third edition printed in 1821 and a fourth in 1822. From the motto and vignette upon its title page, the book was called by many "Death in the Pot" and this term, as a sort of nickname, was even applied to the author.

The treatise on adulterations quickly attracted the attention of publishers outside of England. An American reprint was published by A. Small in Philadelphia in 1820. A German translation, "Von der Verfälschung der Nahrungsmittel und von den Küchengiften," by L. Cerutti was published in Leipzig in 1822, and a second German edition in 1841.

Such in brief was the origin of the modern pure food movement, of which the centennial anniversary has just passed without comment or notice. It is instructive to study this first attempt to accomplish an important reform and to ascertain the reasons of its failure.

(*To be concluded in the December issue*)

Social Sense of Students Measured by University. A new kind of examination—a test of social intelligence—was given to 1200 students entering George Washington University this fall. When the results are in, the professors will have evidence as to which students are good mixers, which are quick to size up situations and people, and which are likely to get along in positions where they must direct other people.

"It is a well-known fact that many students who rate high in general intelligence tests do not make good in later life," said Dr. Fred A. Moss, associate professor of psychology at the university, and author of the social intelligence test. "Some of these make fine school records, but they lack what is popularly called the ability to 'get along in the world.' Since universities are trying to bring out the possibilities in their students and to start them off in some direction where they are likely to have success, we believe that a measure of each new student's social sense will provide valuable data."

The new type of test deals with practical conditions, Dr. Moss points out. The ability of the students to remember names and faces was first tested. Then their success at sizing up a series of social situations was measured. A typical problem in this test was:

"A Harvard graduate is holding a position as caretaker of a small playground. He is most likely one of the following—(1) a drunkard or drug addict; (2) unusually fond of children; (3) unable to adjust to a position of responsibility; (4) a moron."

As a test of keenness at reading faces, a number of photographs of a screen star were thrown on a screen and the students were asked to tell what emotion was being registered on the actor's face. Still another branch of the examination dealt with general information on art, science, literature, politics, and sports, because the wider the range of an individual's interests the more likely he is to understand and get along with his fellows.

Dr. Moss' social intelligence test has already been tried out with several thousand cases. He states that certain parts of it have been used in selection of policemen in Los Angeles and in New York State, but this is the first time that a university has attempted to catalog its new students from the social angle.

Dr. Moss says that the test data will be kept on file and compared with the records of the students in university activities and possibly in their later careers.—*Science Service*

THE MODERN SOAP INDUSTRY

Part I

WALTER C. PRESTON, CHEMICAL DIVISION, THE PROCTER & GAMBLE COMPANY, IVORYDALE, OHIO

Early Adventures in Cleanliness
Rise of the Soap Industry
The Chemistry of Soap
Soap-Making
Saponification
Salting
Purification
Crutching
Milling
Raw Materials
Increasing Field of Available Stocks
Properties Determined by Constitution

Early Adventures in Cleanliness

Man's desire for cleanliness, his search for means of attaining that end, and his gradual success in finding means of a more and more satisfactory character form an interesting chapter in the history of the human race. We may almost point to a nation's cleanliness as an index to its degree of civilization. Egypt and Babylonia knew as well as we, or perhaps better, the value of olive oil for cleansing the body, and how the alkaline waters from leeching wood-ashes could be used for removing grease. It is not known at just what stage in man's development the discovery was made that a compound of these two detergents, oil and alkali, was possible, with cleansing properties superior to either. The "sope" of the Old Testament writers is thought to have been a potash or soda lye, and the first description of a product like our own soap is found in the writings of Pliny, according to whom the Gauls were in the habit of boiling goats' fat with wood-ashes, the resulting product being highly recommended for adding a red color to the hair. The introduction of the soap-maker's art into Italy was not long delayed, as shown by the recent unearthing of a complete soap-making plant at Pompeii. During the Middle Ages the art was kept alive in the Mediterranean lands, particularly in southern France, where Marseilles was for centuries the soap center of the world, due probably to the ready supply of olive oil in that section. In England, tallow and other animal fats were used almost to the exclusion of the vegetable oils of France and Spain.

Rise of the Soap Industry

The modern soap industry undeniably dates from the work of two great French chemists, Le Blanc, who rendered cheap soda available in large quantities, and Chevreul, who first distinguished between *fats* and *fatty acids*, showing that the fats and oils in common use are the result of the combination of fatty acids with glycerine. Thus:

$$\underset{\text{Palmitic acid}}{3C_{15}H_{31}COOH} + \underset{\text{Glycerine}}{C_3H_5(OH)_3} \longrightarrow \underset{\text{Palmitin, a fat}}{(C_{15}H_{31}COO)_3C_3H_5} + \underset{\text{Water}}{3H_2O}$$

The names and formulae of the more important members of the "fatty"

acid series and of the corresponding glycerides are herewith tabulated for reference:

Acids		Glycerides	
Name	Formula	Name	Formula
Formic	$HCOOH$	Formin	$C_3H_5(HCOO)_3$
Acetic	CH_3COOH	Acetin	$C_3H_5(CH_3COO)_3$
Propionic	C_2H_5COOH	Propionin	$C_3H_5(C_2H_5COO)_3$
Butyric	C_3H_7COOH	Butyrin	$C_3H_5(C_3H_7COO)_3$
Caproic	$C_5H_{11}COOH$	Caproin	$C_3H_5(C_5H_{11}COO)_3$
Caprylic	$C_7H_{15}COOH$	Caprylin	$C_3H_5(C_7H_{15}COO)_3$
Capric	$C_9H_{19}COOH$	Caprin	$C_3H_5(C_9H_{19}COO)_3$
Lauric	$C_{11}H_{23}COOH$	Laurin	$C_3H_5(C_{11}H_{23}COO)_3$
Myristic	$C_{13}H_{27}COOH$	Myristin	$C_3H_5(C_{13}H_{27}COO)_3$
Palmitic	$C_{15}H_{31}COOH$	Palmitin	$C_3H_5(C_{15}H_{31}COO)_3$
Stearic	$C_{17}H_{35}COOH$	Stearin	$C_3H_5(C_{17}H_{35}COO)_3$
Oleic	$C_{17}H_{33}COOH$	Olein	$C_3H_5(C_{17}H_{33}COO)_3$
Linoleic	$C_{17}H_{31}COOH$	Linolein	$C_3H_5(C_{17}H_{31}COO)_3$
Ricinoleic	$C_{17}H_{32}(OH)COOH$	Ricinolein	$C_3H_5(C_{17}H_{32}OHCOO)_3$

Of the foregoing, oleic, linoleic, and ricinoleic acids are termed "unsaturated," because not all of the available valence bonds of the carbon atoms are in use; hence the readiness with which they combine with other substances, as with hydrogen, for example. Thus if two hydrogen atoms are added to the unsaturated oleic acid molecule, the saturated molecule of stearic acid results.

The Chemistry of Soap

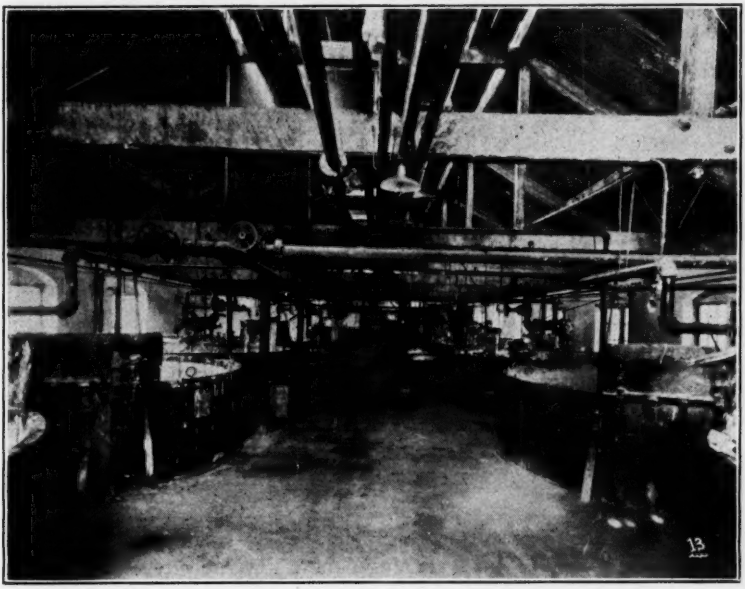
Soaps are the metallic salts of the fatty acids, but for most practical purposes they may be limited, first, to the salts of the fatty acids containing ten or more carbon atoms, and second, to the sodium and potassium salts, which form, respectively, the hard and soft soaps in common use. As in an inorganic salt like NaCl we have the product of neutralizing a mineral acid with a base, splitting off water, so in the soaps we have the product of neutralizing an organic acid with a base. Thus:

$$\underset{\text{Acid}}{C_{15}H_{31}COOH} + \underset{\text{Base}}{NaOH} \longrightarrow \underset{\text{Soap}}{C_{15}H_{31}COONa} + \underset{\text{Water}}{H_2O}$$

Instead, however, of dealing with a fatty acid like palmitic, the soap-maker more commonly has to do with animal and vegetable fats and oils which are largely the glycerides derived from the acids of the preceding table. The union of the neutral glyceride with alkali does not proceed with the same ease as when fatty acids are used, but it does take place, and the reaction in this case is called "saponification," from the Latin "sapo," soap, and "facere," to make. When neutral fat is used in place of fatty acid, glycerine is split off instead of water. Thus:

$$\underset{\text{Palmitin}}{(C_{15}H_{31}COO)_3C_3H_5} + \underset{\substack{\text{Caustic}\\\text{Soda}}}{3NaOH} \longrightarrow \underset{\substack{\text{Sodium Palmitate}\\\text{(Soap)}}}{3C_{15}H_{31}COONa} + \underset{\text{Glycerine}}{C_3H_5(OH)_3}$$

This equation represents the most important chemical reaction that takes place in a soap plant. Caustic potash is sometimes substituted for the caustic soda and there results the well-known soft soap, since potassium soaps are usually softer than the sodium soap of the same fatty acid. Also, instead of one fat, like palmitin, the soap-maker's stocks consist of a mixture of many glycerides and fatty acids, chiefly laurin, myristin, palmitin and stearin of the saturated series, and olein, linolein, and ricinolein of the



View of a Kettle House. The kettles extend two floors below that shown.

unsaturated series. Probably the individual fat molecules are commonly derived from more than one fatty acid and we have such mixed glycerides as $(C_{15}H_{31})(C_{17}H_{33})_2C_3H_5$.

Soap-Making

Of course, there are more methods than one of making soap, but by far the most common in this country is the boiled, settled process. Practice varies from plant to plant, but in general, the procedure in America involves three steps, saponification, washing, and settling, each of these in turn involving more than one operation.

Saponification

For the saponification, commonly known as "killing," the fat and lye must be heated together until union occurs. This is not always easy,

and especial difficulty may be encountered in getting the reaction started. The higher the temperature and the greater the area of the surface of contact between the oil and lye, the more quickly the reaction proceeds. For this reason it is essential that an emulsion of oil and lye be formed, for breaking up the oil into minute drops increases the surface of contact many thousand-fold. The saponification reaction itself generates heat, and as the soap is formed it acts as an emulsifying agent, and so when once started the reaction tends to accelerate itself until checked toward the last by the decreasing concentration of one of the reactants.

In the large kettles of the industries saponification is a process requiring several hours; but given heat and time, the reaction finally goes to completion, or so nearly so that only traces of unsaponified fat can be found by chemical analysis. The skilled soap-maker becomes surprisingly accurate in his judgment of the condition of the soap, and by tasting for free lye, by squeezing between the fingers for greasiness and body, and by watching the soap as it cools upon a wooden paddle, he has little difficulty in deciding when to have the chemist test it for completeness of saponification.

Salting

When this stage of the process is complete, the contents of the kettle are a thick, pasty mass from top to bottom, consisting chiefly of a mixture of soap, water, glycerine, and excess lye. As the glycerine is the most valuable by-product of the industry, it must be recovered from the soap. For this reason, salt is added to the kettle until the soap is "salted out" or "grained out," that is, rendered insoluble by the large amount of electrolyte in solution. It then separates from the water as soft grains, which rise to the top of the kettle, floating upon a lower, clear, liquid, aqueous layer. This lower layer contains very little soap, and consists of water in which is dissolved the major part of the glycerine, salt, lye, coloring matter, and impurities. The soap layer above contains little of these; but even small amounts must be removed, and so, after being allowed to settle for some hours, the clear lower layer is pumped off for the recovery of the glycerine, while the upper, soap layer remains in the kettle for further treatment. This consists in boiling it one or more times with strong lye, for the double purpose of washing out the last traces of glycerine and colored impurities, and of insuring complete saponification of any residue of fat that may have escaped the first treatment. After this washing with strong lye, toilet soaps in particular are frequently boiled one or more times with strong salt brine, in order to remove all of the excess alkali, leaving in its place the unobjectionable salt. The salt content is kept so high during this washing process that the soap remains undissolved, and when the contents of the kettle are allowed to settle, the soap rises to the top,

and the salt solution can be drawn off from the bottom as though from a separatory funnel.

Purification

The next step in the process is the "settling," "fitting," or "pitching" of the soap, which at the conclusion of the salt washes is still grained out, and contains several per cent of salt. When a small amount of water is now added to the kettle, the salt present is diluted and the soap begins to go into solution, and forms a smooth, pasty mass once more. The skilled soap-boiler must adjust the concentration of salt and water to a rather nice point, within fairly narrow limits, so that upon standing a separation into two layers will take place. The upper layer of "neat" soap contains approximately 30% water and 70% soap, while the lower layer is thin, liquid, usually dark in color from impurities, and hence called "nigre," and contains only 30 or 40% soap. The separation of the nigre is the final purification which the soap undergoes. Coloring matter, impurities, salt, free alkali, etc., all concentrate in the nigre, leaving the neat soap more or less pure, depending upon the efficiency of the pitching operation. After the kettle has been allowed to stand undisturbed for several hours, or often for days, the neat soap, which is still so hot as to be melted and liquid, is pumped away for further treatment in the crutcher, while the nigre can be worked over again and used in a poorer grade of soap.

The kettles used for the boiling are of iron, either cylindrical or square, and usually with a cone-shaped bottom to facilitate draining. Formerly they were much smaller than now, and were heated by open fires; but the use of steam has become almost universal, since it is far easier, does not entail danger of burning the charge, and can be blown through the soap from the bottom of the kettle, and in this way effective agitation is attained.

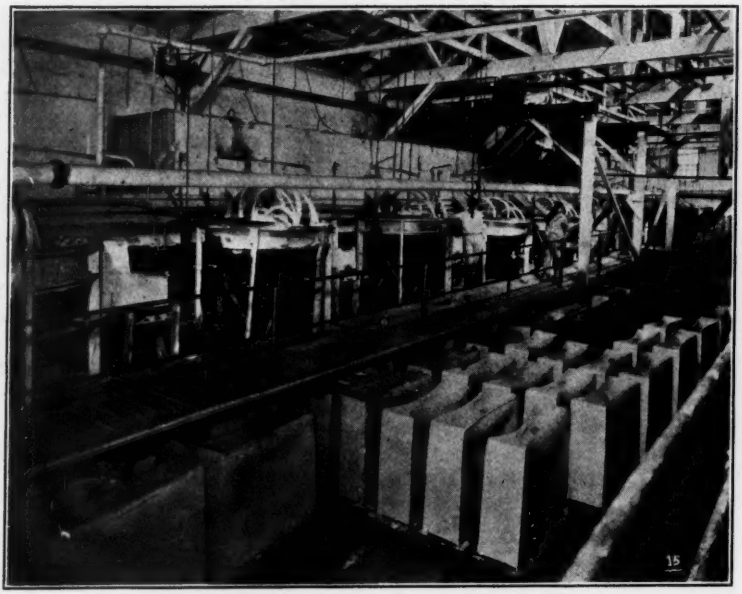
Crutching

After the separation of nigre from neat soap, the latter is pumped to the crutchers or mixers, where it is stirred with revolving paddles or screws. The objects of crutching may be varied. The texture and uniformity of appearance of the soap, which would otherwise be streaked and mottled, are here improved, and it is here that air is beaten into floating soaps by giant egg-beater mechanisms. Coloring matter, perfumes, medicinals, builders that are intended to improve the soap, and sometimes fillers whose chief known effect is to cheapen the product, are added in the crutchers and mixed thoroughly. These builders and fillers will be taken up more fully in Part II of this paper. After crutching, the soap may either be cooled rapidly by bringing it in contact with a cold water system, or it may be poured into large iron frames and allowed to cool and solidify slowly. The sides of the frames are removable, and after several days,

when the soap has become hard, they are taken off, and the soap can then be cut into the desired sizes, molded, stamped, wrapped and boxed, ready for the market.

Milling

Many soaps, especially those for toilet use, are subjected to another process, known as milling, which consists in rolling the soap into thin ribbons, and then by means of heat and pressure molding it into the desired bar form. Milled soaps have a very uniform texture, they do not warp



Soap Crutchers. The hot soap from the kettles is here thoroughly mixed.

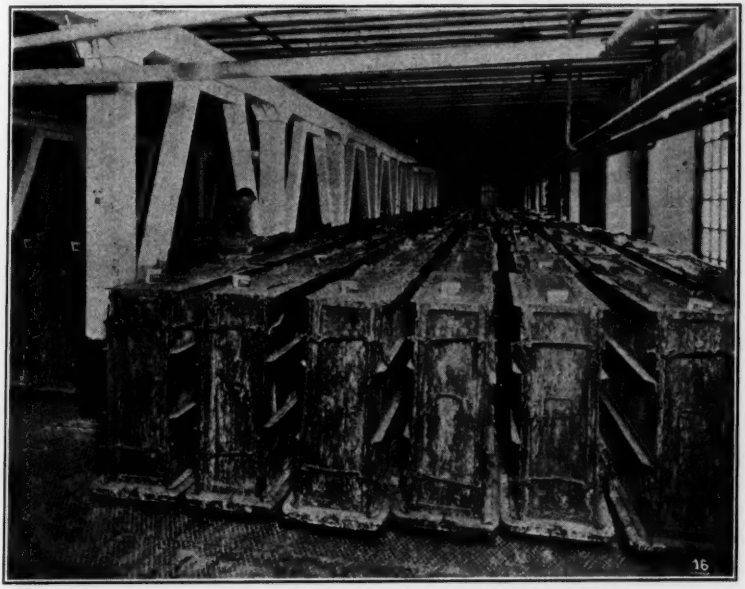
upon aging, and they have a much lower water content than do other soaps, due to the heat treatment which they receive.

Raw Materials

Such, in brief, is an outline of the general procedure followed in the majority of our modern soap plants, although, of course, variations and indeed entirely different processes are in vogue at different places. Simple as the chemical reactions may seem, the chemical problems involved, many of them yet unsolved, are countless. The study of the fatty stocks used is alone one of tremendous importance and complexity. As scientific knowledge has advanced, and the uses to which the natural fats can be put

have become more numerous, more and more of the fats have been diverted from the soap trade into edible channels, and the soap-maker has been compelled by economic forces to search far and wide for his soap stocks, and to discover new sources for his supplies.

Of the animal fats, lard and tallow, both beef and mutton, have long been in use, although at the present time the demand for lard for edible purposes precludes its use as a soap stock. Tallow has for centuries been the standard soap stock of the English-speaking peoples, and makes a



Soap Frames. The soap drops from the crutchers into frames in which it solidifies.

very serviceable soap, whether for toilet, household, or laundry use. Due to its high stearin content, its solubility is not great but its lather, while not profuse, is permanent and hence excellent for shaving purposes.

Throughout the Middle Ages, olive oil was the almost universal soap stock of continental Europe, and the well-known Castile and Marseilles soaps resulted. Olive-oil soap is unexcelled in its mildness, and gives a fairly free, although somewhat thin lather. Its excellent qualities can be attributed largely to the high per cent of olein which it contains, since sodium oleate is one of our best soaps. At the present time in the United States, much of even the pure so-called Castile soap on the market contains other constituents which are blended with the olive oil in order to

improve its quality or to replace a part of the more expensive grades of olive oil which are necessary to produce a white soap.

Palm oil has also for years been considered a good soap stock, yielding a firm product which gives a more permanent although less rapid and profuse lather than does olive-oil soap. The soap from coconut oil possesses unique properties. It is unusually rich in the lower members of the fatty acid series, lauric and myristic acids in particular. The soaps from these lower acids are very white and hard, and lather profusely, even in cold water. They are of unequaled value for use in salt water. Other soaps are almost useless in sea water, since they are rendered insoluble by the salt present and so do not lather. Coconut-oil soap, however, dissolves readily and lathers so freely in sea water that it is the universal marine soap. Its lather is of rather transient nature, and, unfortunately, it has an irritating effect upon the skin and an unpleasant "bite" when in contact with the tongue and for this reason it is usually blended with large quantities of other gentler soaps.

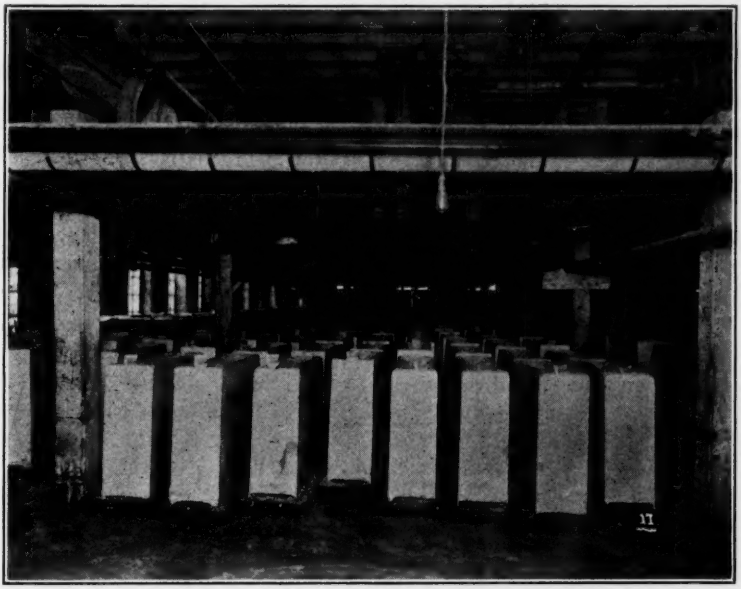
Increasing Field of Available Stocks

The use of stocks rich in the more unsaturated acids such as peanut oil, corn oil, castor oil, fish oil, etc., was formerly attended with danger, as such soaps are likely to be very soft, and turn rancid readily with accompanying unpleasant odor and darkening in color. Many such oils can be made satisfactory, however, thanks to the recent rapid strides in catalytic hydrogenation. Cottonseed oil, for example, contains large percentages of unsaturated acids, and its soap is not desirable, since it is very soft, rancidifies rapidly, and becomes brown and offensive. But when heated in contact with gaseous hydrogen and a finely divided nickel catalyst, the hydrogen combines with the unsaturated bonds of the oil, forming olein and even the solid stearin, and we obtain a stock capable of forming a beautiful, firm, white soap, which lathers as well as does the original, and which keeps well. As a result of the extensive use of catalytic hydrogenation, the list of soap stocks has been greatly extended within recent years, and the end is not yet in sight. Thus, fish and whale oils, which a few years ago could be used only for low grade soaps, are now in their hydrogenated forms to be listed among the important soap stocks.

Low grade greases have been put to service by the use of the "Twitchell Process" or other methods, which consist essentially in splitting the fatty matter of the grease into fatty acid and glycerine. The two are separated from one another, and may be purified by distillation under reduced pressure. The free fatty acid is then neutralized by NaOH or Na_2CO_3, forming soap directly. In the Twitchell Process the fat is hydrolyzed catalytically by boiling it with dilute sulfuric acid and the "saponifier" or

"Twitchell reagent," which is essentially a stearo-naphthalene-sulfonic acid. At the present time, in Germany and the Scandinavian countries, Geoffrey Martin states that over 75% of the total soap produced is made directly from fatty acids obtained either by the Twitchell or some other process.

Even the most hurried review of the soap stocks would be incomplete without mentioning rosin, since it is present in practically all of our yellow and brown household and laundry soaps. Rosin is a mixture of organic acids of high molecular weight, all grouped under the inclusive term "abietic acid." Being made up of acids, it therefore combines directly



Soap after cooling and removing the sides of the iron frames.

with sodium hydroxide or carbonate to form sodium rosinate or rosin soap, which is a soft, sticky, brown mass, readily soluble in water, and possessing considerable lathering and detergent properties. It is never used alone, but when added to soap it softens it, increasing its solubility and rendering it less expensive. It is therefore, a valuable soap ingredient, although on account of its color it cannot be used in white soaps, and because of its tendency to adhere to the fibers of the cloth, it cannot be added to the textile soaps such as are used in the cotton, silk, and wool industries for the preliminary treatment of their goods. For household use, however, its beneficial effects are such that it cannot be regarded as an adulterant.

Properties Determined by Constitution

From the preceding hasty review of the soaps derived from the more common fats, as well as from a more careful study of the pure soaps derived from the individual fatty acids, we may trace a few relationships between soap properties and soap formulae. As we ascend in the fatty acid series from acetic to stearic, we find that the sodium salts possess no soap-like properties until we reach caproic acid, and that such properties do not become marked until we reach sodium caprate, $C_9H_{19}COONa$. The salts of the next four acids are typical soaps. The solubility of the soaps decreases as we pass from the laurate, through the myristate and palmitate, to the stearate, and for cold water washing the stearate is almost valueless. Sodium laurate and myristate give a profuse lather even in cold water, yet in the case of the laurate it is of very transient nature, while the less profuse lather of the palmitate and stearate is more lasting. All these soaps are white when pure, and are firm when possessing a water content of about 30%. The unsaturated soaps are very soft, very soluble, lather freely, although at high temperature the lather is transient, and are more or less subject to rancidity and discoloration.

In a later paper it is planned to take up some of the theories of the chemical structure and colloidal behavior of soaps, as well as a discussion of a few soap specialties, and of the substances commonly added in the crutcher.

(*Part II will appear in the December issue*)

A NEW ELEMENT—"WOMAN"

Symbol—WO

A member of the Human family.

Occurrence: Can be found wherever man exists. Seldom occurs in the free or native state. Quality depends on the state in which it is found. With the exception of Massachusetts state, the combined state is to be preferred.

Physical Properties: All colors and sizes. Always appears in disguised condition. Surface of face seldom unprotected by coating of paint or film of powder (composition immaterial). Boils at nothing, and may freeze at any moment. However, it melts when properly treated. Very bitter if not used correctly.

Chemical Properties: Extremely active. Possesses a great affinity for gold, silver, platinum, and precious stones of all kinds. Violent reaction when left alone by men. Ability to absorb all sorts of expensive food at any time. Undissolved by liquids, but activity is greatly increased when saturated with spirit solutions. Sometimes yields to pressure. Turns green when placed next to a better appearing sample. Ages very rapidly. Fresh variety has great magnetic attraction.

NOTE: Highly explosive and likely to be dangerous in inexperienced hands.—*Voo Doo*

THE SCIENCE TEACHER'S OPPORTUNITY

FRANK M. LIFE, UNIVERSITY OF ARIZONA, TUCSON, ARIZ.

That holding a position as teacher of science in one of the Nation's high schools is fraught with vast opportunity, is best appreciated by those who think upon it most. By science teacher I do not mean the instructor in history, language, or literature. Nor do I wish to include the instructor in mathematics. The sciences to which I desire to direct attention are biology, chemistry, and physics. It is true that history, language, and literature may be studied as sciences, and mathematics is essentially a science so closely related to the sciences with which we wish to deal as to render little progress in these possible without considerable training therein. This does not decry the importance of physiography, physical geography, geology, astronomy, etc., but simply recognizes that they are not so fundamental in the secondary-school curriculum.

It is possibly true that, except for matter and its characteristics, there would be nothing out of which to build knowledge and therefore nothing upon which to base mental culture or mind training, certainly nothing out of which to build character. It is therefore largely in terms of the facts of nature as revealed in biology, chemistry, and physics that we are enabled to think at all; and it is, when realized in this light, that the teacher of these sciences gets a real grasp upon, and realization of, the importance of his opportunity.

As the writer sees it, public education is, more or less perfectly, serving: *First*, to fit one for a proper place in the commonwealth of which he is a part. *Second*, to render him, efficiently serviceable in the development or evolution through which man is called upon to work out his own destiny. It is, however, with the former purpose, that of fitting for appropriate citizenship in the state and nation, that we are most intimately concerned as teachers in the schools supported by public funds.

In the class-room an inspiring situation exists. The average American youth is eager for the truth, to him, locked up in nature. The tactful instructor will endeavor to have his pupil experience an appeal from the world about him and a stimulus to thought from his environment. The opportunity of instructing the eager and alert youth of our land is one very much worthwhile. The undiscerning teacher, who takes no pleasure in observing the flash of grateful approval on the countenance of the young man or young woman in whose mind a new idea has just taken birth, cannot justify his place in the teacher's chair. There is no better motto for the teacher to have before him, during all his wakeful hours, than the one recorded in the Good Book in these words: "Study to show thyself approved."

The best way to gain the approval of a group of individuals is by leading its members into new thoughts by exploring the storehouse of truth that

exists in matter about them. The common, everyday things are the best sources for material in which to disclose the most fascinating facts. For example, a common plant or a well-known animal in the hands of a really competent and inspiringly interested instructor may be made a real circus for a class of interested observers or participants in uncovering the activities of nature. Or the same function may be served by some commonly familiar substance in the hands of a class under the instruction of an interested and inspiring teacher in chemistry. A number of years' experience in teaching physics has revealed the power of an instructor to hold a group spell-bound while a subject as prosaic as the Properties of Matter is being inquired into. The same may be said of Accelerated Motion, Universal Gravitation, Composition of Forces, Resolution of Forces, Mechanics of Fluids, Wave Motion, etc.

To the beginner in the teaching profession this may seem preposterous and unattainable; and, except for the possession, on the part of the instructor, of an extensive knowledge of the subject and a tactful and sympathetic attitude toward the student, it *is* unattainable. A teacher whose sympathies are broad and whose compassionate consideration for the weaknesses of the girl or boy whose intellect he is trying to awaken is such as to unconsciously compel an attentive and interested attitude, is the one for whom the School Board is, or should be, looking and the one whom the community is proud to possess.

We have already said that an important function of the school is to make good citizens for the community, state, and nation. Let us inquire into the specific and peculiar aptitude of laboratory subjects to contribute toward this end. What are some of the attributes of valuable and efficient citizenship? They are self-reliance, tact, honesty, integrity, regard for natural law in the material and spiritual world, etc. There are probably more failures and blasted careers because of a lack of ability to encounter, with confidence and self-reliance, the problems that confront one in any walk of life than from any other cause. Science reveals fundamental principles in accord with which all advancement and adjustment must come. In fact, the writer derives much satisfaction from thinking that the endeavors of science are man's approach to simplified truth made manifest in all nature by an all-wise Creator, and that this truth embodies the thought of that Supreme Intelligence.

Thus knowledge of any branch of true science is a long step toward placing the possessor more nearly in harmony with the universe in which he finds himself. And then familiarity with the scientist's method of attack upon a realm of unexplored and seemingly hidden knowledge, is another acquirement of vast import in establishing a proper degree of self-reliance. Scientific methods, or we might call them scientific habits, are marvelously conducive to independent thinking and greatly enhance the value of judg-

ments from whatever premises they may arise. This is productive of stability of character, a quality most wholesome in adolescence as well as in adult life. The healthful attitude of the science investigator, or experimenter, is that of an interested but unbiased onlooker and not a real participant. This is an unusually important trait of character that often helps to keep us out of activities and discussions in which we have no reason to participate.

It is said that one or two commercial failures have preceded the final success of a large percentage of those who have built up great fortunes. In other words, they have misjudged but have profited by their failures. Perhaps no branch of learning so much as experimental science prepares one to successfully encounter and surmount difficulties. This is largely because the experimenter learns to interpret his failures and develops the habit of securing all available data before accepting a conclusion.

While the high-school curriculum has been formulated with a view to furnishing the mental training and development necessary to efficient citizenship, the choice of particular subjects to be pursued has also been made with a view to simultaneously furnishing a fund of practical facts which seem best fitted to adapt the individual to his or her life environment. The importance of the facts of biology, chemistry, and physics cannot be overestimated. A knowledge of biological facts induces directed development and evolution of domesticated plants and animals; is conducive to discovery of and belief in means of eradicating obnoxious and parasitic plants and animals; and leads to the individual's intelligent care of self—a most important factor in community life. It, of course, is upon this knowledge that public as well as private hygiene and sanitation are based. That chemical facts are of great practical significance is evidenced by the use made of them in the kitchen, treatment of soils, manufacture of foods, production of dyes, manufacture of implements, elimination of foul or poisonous gases, preservation of materials, production, and utilization of by-products, and in practically all the arts of peace and war. To physics belongs the high honor of furnishing a basis upon which is built an understanding of all the other sciences and of affording knowledge which puts the individual in thought connection with his surroundings in whatever environment he may be placed. It may not seem usurpation of an opportunity to say at this juncture that no science is so fundamentally an essential part of every one's knowledge as is physics.

This is distinctively a scientific age. Advancement at the present time is rapid, not so much because we have in the world a few men and women who are capable of and *are* doing research work, but rather because there is a vast number of interested and intelligent seekers for new truth. This large group of investigators is supported by a sympathetic public that eagerly digests the results of the scientists' latest discoveries. This

appreciative public is the result of the public-school science teacher's efforts. Even the investigators, or scientific experts, for the most part, received *their* urge toward a scientific career from their public-school associations. The subject-matter of the public-school sciences must of necessity undergo some modification in order to adjust the presentation to modern conceptions. As a result high-school botany, zoölogy, chemistry, and physics have since their inception undergone marked modifications and this process is bound to continue. This creates no distrust, however, in the mind of the fair thinker, for he accords to all branches of knowledge barriers and limitations which he expects will gradually be removed as man's knowledge and capacity for thinking increase. In fact, a greater distrust is aroused if no change or advancement is observed.

Our present notion of the part played by electricity in the constitution and properties of matter has greatly modified our interest in and methods of attack on practically all scientific problems. In all science "we are now looking for causes where before only effects were seen." Modern research leads to discoveries, highly technical and complicated, but the conclusions are for the most part simple, certain, and fundamental. Man is continually reminded that any theory which may be formulated is bounded by the unknown, yet he is encouraged by the fact that any theory once arrived at is rarely, by additional discovery, proved false. In other words, "science is revolutionary in no destructive sense." "Man is almost at the point where his continued existence is dependent upon his power arrived at through knowledge rather than through struggle." Recent additions to knowledge have intensified our realization of a lack of knowledge; hence the present inclination toward research.

To cope with this changing status of the sciences, educational associations and departments, feeling the responsibility for a proper dispensation of the new with respect to the old, have called extensive conferences for deliberate consideration of the points at issue. Pursuant to this idea the National Educational Association at the Saratoga meeting in 1892 created a committee, known as the Committee of Ten, whose function it should be to consider, in conjunction with representative teachers of the various subjects in the secondary schools, the proper limits of these subjects, the best methods of instruction therein, the most desirable allotment of time for the subject, and the best methods of testing for attainments therein. The subjects of the secondary-school curricula were grouped under nine heads and as many conferences were arranged, with ten representatives at each conference. Accordingly physics, astronomy, and chemistry constituted one group while botany, zoölogy, and physiology constituted another group. Both these groups convened for conference at the University of Chicago. In the former group-conference ten states were represented while in the latter nine states were represented. These conferences rendered their

reports to the general Committee of Ten which, in turn, after extensive deliberation completed its report in November, 1893.

There is a general agreement that this report is the most important educational document ever issued in the United States. It was published by the National Bureau of Education at Washington at public expense, but the edition was not sufficient to supply the demand, for secondary schools everywhere were eager to avail themselves of the suggestions therein contained. To meet this demand the American Book Company also issued an authorized edition which they distributed at cost. The report of the Committee of Ten emphasized the absolute necessity of laboratory work in physics, chemistry, and biology, and the keeping by the student of laboratory note-books. The study of a text-book with accompanying lectures and demonstrations was made imperative. It was also urged that the science teacher requires for good instruction more time for a given number of class hours than does the teacher in mathematics and language, and that this indispensable labor should be allowed for in programs and salaries. That the examination should include both a written and laboratory test was agreed. It set out in considerable detail extensive outlines of the work to be pursued in each of these sciences. This report became the criterion of procedure in approving secondary schools throughout the states.

The organization and coördination of the science work of the secondary schools in accord with the report of the Committee of Ten was attended by such advancement in the sciences that the report gradually became superseded in practice and represented less than the record of actual accomplishment of the schools. To meet this new situation, in 1913, a committee of fifty science teachers, under the auspices of the National Bureau of Education, began work on a revision of secondary school science. After a period of seven years of observation and research this committee made its report in 1920. During this long period of study, progressive work was undertaken and improvements developed were adopted by many of the secondary schools. This report suggests an extensive revision of science instruction, both as to content and methods of procedure. The objectives are classified as "educational" and "specific." The educational objectives being health, worthy home membership, vocation, citizenship, use of leisure time, and ethical character; while the specific objectives are interests, habits, abilities, methods of solving problems, purposeful activities, information, cultural values, and aesthetic values. The problem type of self-activity on the part of the student is strongly emphasized. A sequential science content is suggested that would be cultural and sufficiently vocational to educate as well as train. The adaptation of instruction to local environment is recommended. Utilization of knowledge already possessed by students out of which to construct a knowledge of science is suggested in so far as it seems possible.

The American Association for the Advancement of Science, by action of its Council in session at Cincinnati in December, 1923, authorized an investigational project with a view to determining the proper place of science subjects in general education with special reference to American school curricula and to social objectives. A committee was authorized to take charge of this investigation and funds to bear necessary expenses were provided. This committee feels that the unprecedented recent development of the sciences and the rapid introduction of scientific knowledge and scientific thinking into the everyday activities of life suggest that steps be taken toward bringing about a more general realization of the true setting of science in modern education. The committee through its chairman, Otis W. Caldwell, 425 West 123rd Street, New York City, is inviting suggestions as to plans of procedure in the investigation entrusted to it. In this connection it might not be out of place to suggest that it would at least be an encouragement to this committee if the Teachers' Association of each state would proffer any coöperation which the committee might see fit to utilize and suggest any points of attack which may occur. There is no reason why any state, although its population may be small, cannot play as important a part as any other state in solving such problems as these.

In some states, of recent years, as high as 75 per cent of those of high-school age are not in attendance at high school. It is not uncommonly that more than one-fourth of the number of those whom we have a right to expect to be enrolled in high schools are not found there. We either should not expect these persons to be in the high school or we should be able to explain why they are not there. There is no doubt that a certain percentage of those not in high school have absented themselves for good and sufficient reasons. It is as well for them and others that they are not there. They may be so mentally incompetent as to make attendance at high school undesirable and the acquisition of a high-school education impossible. These we would not desire to entice or coerce into attendance. There is another class of persons of high-school age—those who are really capable but uninterested in securing an education. Of course the home should properly take a portion of the blame for their indifference. It may be that the grade schools are at fault and have not delivered them to the high school with an inclination to continue their studies. However, I believe it most healthful to the secondary school to look within itself for the cause of a lack of interest on the part of the ones refusing to take advantage of its educational opportunities. The science departments of the high schools should assume at least one-fourth of the responsibility thus placed. In fact, I am wondering whether these departments should not shoulder as much as one-half the responsibility.

It is generally conceded by those giving secondary education close consideration that not less than one-fourth of a well-rounded educational

course, in order to make it in a practical way as helpful as possible, should be devoted to the natural sciences. Probably it is also true that the larger portion of the stimulus which induces a desire for attendance at high school should be furnished by the study of the sciences. This makes us inquire what is wrong with high-school science as it is now taught. All of the answer is not quick in appearing, but at least some of its significance may be easily sensed when we think over the organization of the science courses as to content, sequential presentation, methods of instruction, etc. A few nights ago the writer attended a presentation of "Treasure Island" by the marionettes or puppets. The inanimate figures produced their emphasizing gestures when the voice called for it so that there was a remarkable coördination and strong appeal to the auditor. These miniatures seemed to speak and lead the audience into their sympathies. As I see it, the organization of our high-school science and its presentation sometimes—perhaps often—fails to bring about psychological coördination and our gestures to this or that event of nature fail to cause the child to hear nature speak. The end desired is thus entirely lost on account of the inopportunity of the occasion. The child thereby loses interest, soon becomes indifferent to the efforts of the high school intended for his instruction, and finds greater interest in things outside the school. That this child was not to blame for making such a decision is plain. Nor is it necessarily true that the teacher is to blame, although in most cases he must bear a portion of the censure. The teacher must not fail to keep the sympathetic interest of his pupil.

As community interests become more artificial and complex, instruction in the natural sciences must become more practical and vocational. All industry and practically all community activity depend, for their development and success, upon the facts and laws of the sciences. If in teaching these sciences we give a practical turn to the study we shall awaken interest on the part of the student both in the industries of the community and in the sciences as well. I am inclined to think our present high-school curriculum is inadequate to meet the demands upon the high schools as they now exist. It is easier to believe this than to explain what is positively wrong with our modern high school or to propose a cure. It is sincerely to be hoped that the committee appointed by the American Association for the Advancement of Science will be able to analyze the present difficulty and suggest a remedy. It is sure, however, that whatever effective modifications are proposed and accepted will not originate with the committee but will be suggested by persons already in the service of the high schools. Real reforms do not originate outside of the organization that is to be reformed. No one is so capable of discovering the specific defects of our modern high schools and the remedies therefor as the teacher therein. This assertion would not be made if the writer were not conscious

that many stalwart intellects are to be found among the science instructors of our high schools.

There is no source from which a committee could be raised for the consideration of this question that would seem so appropriate as the American Association for the Advancement of Science. This is not a "tempest in a tea-pot" but is a consideration which touches every individual and upon which the industrial life and educational status of the next generation will, to a very considerable extent, depend. It may be that no radical change in science instruction will result but, if, upon deliberate consideration, it should be found necessary to discard our present high-school science text-books to make way for the proper onward march of science development in this country, then that which should be done *must* be done. That such a course would meet the opposition of the ultra-conservatives is to be expected and it might be that some opposition would arise from a few publishers. No opposition of material import would arise, however, if a clear-cut and justifiable program were outlined. When we study the history of the secondary schools in our country we are made aware that every step of advancement made in the secondary schools was the result of a general acceptance of changes of curriculum, methods of instruction, or personnel of instruction tried out by one or more schools with marked success. When we realize that true advancement and improvement in our secondary schools have come in this way, and will of necessity again come in like manner, every high-school science teacher must realize that he or she has an equal opportunity and not only an equal opportunity but equal responsibility with every other such teacher in bringing about needed reforms.

As a teacher of science for more than a quarter of a century and a continuous observer of scientific development for a considerably longer period than this; and at all times having an acute interest not only in the development of these sciences but in their dissemination through the public schools, I feel confident now in contending that the high-school science curriculum needs a thorough renovation and revision. Such a revision should eliminate much duplication of teaching which now exists, conserve the teaching force, give the greatest practical or vocational setting consistent with pure science, and economize expenditures for equipment; but, most of all, it should be calculated to stimulate a greater interest on the part of all students and thereby serve extensively in accomplishing the purpose for which the high school is designed.

To recapitulate: I have endeavored, as briefly as possible, to emphasize: The importance of the sciences. Our utter dependence upon *matter*, the objective part of any science. The purpose of public education. The mutual helpfulness of student and instructor. The enticing appeal of the facts of nature to the interested observer. Value of the teacher who

can drown personality in the attractions of the subject. Importance of laboratory studies in the development of character. Extreme value of broad information, especially of current developments, on the part of the teacher. Evolution of the school itself as to content and methods of procedure dependent upon development in the sciences and part played in this by the effectiveness of the National Educational Association, National Bureau of Education, and American Association for Advancement of Science in creating opportunity for the science teacher. Lack of interest on part of high-school students. Placing responsibility for limited helpfulness of high school. Suggestions as to field of revision of secondary-school system. The teacher, the ultimate individual on whom responsibility really rests. Therefore the teacher's great opportunity.

Salt Helps Workers Stand the Heat. How a pinch of salt in the drinking water prevents the exhaustion of workers in hot coal mines and steel plants was told before the Institute of Mining Engineers by Sir Josias Court recently. A similar discovery was made by Prof. Neville Moss of the University of Birmingham. He found miners who succumbed rapidly when working in a temperature of about 100 degrees were able to endure it better when their drinking water contained even one-fifth of a per cent of salt.

Dr. J. B. S. Haldane, an English physiologist, explains that during work at a high temperature the body gives off much perspiration and with it a large amount of salt; to this depletion of salt the physical exhaustion is partly due. The addition of salt to their drinking water makes up for the loss.—*Science Service*

Kitchen Soap Kills Germs. Soap has a value as an aid to health even greater and more direct than has hitherto been suspected. The ordinary routine of dishwashing and laundering or cleaning the face and hands is fatal to germs of such dangerous diseases as pneumonia, diphtheria, blood poisoning, and other serious infections. Dr. John E. Walker of the Service Laboratory of the Army and Navy General Hospital at Hot Springs, Ark., has just concluded extensive experiments which showed that common soaps were effective germicides in at least three types of infections, while soap made with coconut oil was markedly destructive to the organisms of typhoid fever.

The soap in greatest use around hospitals is the "official soft soap." The substitution of coconut oil for the linseed oil used in making this soap, Dr. Walker said, would render it germicidal against the typhoid bacillus as well as against the other three organisms. Although this change would make the soap more irritating to the skin, the change would be desirable, and it would be useful in case of typhoid epidemics.

All the soaps tested were more antiseptic at higher temperature. The organism causing boils, known technically as Staphylococcus aureus, completely resisted all soaps, even at a higher temperature, except a sodium resin soap.

Dr. Walker found that when the hands were washed with ordinary care the lather formed contained about eight per cent of soap. This amount he said was more than enough to kill the pneumonia, diphtheria, and streptococcus bacilli. The most careful washing of hands, however, did not kill the staphylococcus or boil-forming organisms, which showed that soaps alone could not be relied upon for complete surgical sterility.

In spite of claims put forth by manufacturers of special soaps, they were found to be no more effective than the average household kind. Foreign substances mixed with the soap often interfered markedly with the germicidal action.—*Science Service*

THE THEORY OF SALT CRAVING

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Nearly all text-books upon biological and physiological chemistry, in dealing with the phenomena of salt craving, present, as the most probable explanation, the theory advanced by G. von Bunge. It is true that some, especially the newer works, cite facts that are not in harmony with this theory, but, almost without exception, the opinions of Bunge receive the most space and emphasis. There has not been, so far as I am able to find, any attempt to gather all the evidence upon the question and submit this theory to a thorough test.

After carefully reviewing every available source of material bearing upon this subject and weighing the mass of evidence thus obtained, it seems that a very convincing case may be built up against Bunge's explanation. After first briefly presenting the work of Bunge and his conclusions, some of the contrary observations will be enumerated.

The Work of Bunge

The most persistent effort to explain salt craving was made by Bunge[1] and this probably suggests the reason for the wide acceptance of his theory. By reading a great number of works of travel, by interviewing, either personally or by letter, travelers in various countries, and by experimentation, he collected a mass of material. His theory certainly deserves a careful examination.

Many of his observations cover the use of salt by herbivorous animals and the indifference to it upon the part of the carnivorous animals. The difference in the types of foods is said to lie in the relative amounts of sodium and potassium; in the food of the carnivora they are about equal, but the potassium is much more abundant in the food of the herbivora. This brings about a double decomposition reaction with the sodium chloride of the blood, thereby resulting in the kidneys removing the potassium salt, potassium chloride, and the newly formed sodium salt. The organism thus becomes poorer in sodium chloride and he supposes that fresh additions of potassium salts would result in fresh losses until a serious condition would be reached. Such, in brief, is his theory, which is always quoted wherever the question of salt craving is discussed.

The Case against Bunge

The work and opinions of numerous investigators, bearing both directly and indirectly upon the subject, serve to raise serious objections to the interpretation of this craving for salt advanced by Bunge. The more important of these may be condensed into a very convincing case.

1. Taste.—Bunge stresses the point that vegetables are unpalatable without the addition of salt, which thereby widens our range of food stuffs.

In this connection it is notable that fruits, which contain as wide or even wider ratio between sodium and potassium do not require salt to render them palatable, depending rather upon other factors. Even in the case of some vegetables, such as lettuce, tomatoes, and sweet potatoes, many people prefer the addition of sugar. Moreover, it has been shown,[2] that the taste quality of salts is dependent not upon the cations, but upon the anions although it is true that sodium serves to intensify the salty taste more than potassium does. Many cases are to be found, Bunge recording one himself, where potassium salts have been used. It is a need, then, for some condiment to relieve the otherwise "flat" taste of certain foods, but not necessarily must this be sodium chloride.

2. **Replacements.**—By ingesting 18 grams of K_2O and noting that the excretion of Na_2O in the urine increased 6 grams, Bunge believed he had proved that by double decomposition potassium replaced the sodium in the blood and that if this process continued, eventually a serious shortage of sodium would result. He states, however, that "Experiments of this kind have so far not been made." H. G. Miller[3] investigated this very point and found that after a twenty-four hour rise, in sodium and chloride excretion, had taken place, the elimination of these elements returned to normal or even fell below normal, although the ingestion of large quantities of potassium salts was continued. This flatly contradicts one phase of Bunge's explanation.

3. **Excretions.**—A defect in the methods employed, not only by Bunge but by other investigators also, lies in the fact that their experiments involved merely an analysis of the urine. It has been pointed out[4] that salts of both sodium and potassium may be eliminated in sweat, in tears, and in the feces, while pathologically even other possibilities may enter in. Potassium compounds can and have been obtained in quantity from wool washings, to cite but one example, and the feces do, under certain conditions, contain some of these salts. The urine will, of course, include most of the salts of these elements, but the other factors can hardly be entirely ignored.

4. **Composition.**—If the only difference in the composition of the foods of the herbivora and the carnivora were in the relative amounts of sodium and potassium, that fact would be significant, but such is not the case. Vegetables in general, have higher water contents than animal foods and the latter are deficient in or devoid of carbohydrates. It has been demonstrated[5] that variance in the composition of foodstuffs as regards carbohydrates, proteins, fats, and water will materially influence the actions of inorganic salts. Slight differences in the amounts of these components have produced contrary effects. A mere comparison, then, of the relative amounts of sodium and potassium, when there are other variables, is hardly adequate.

5. Substitution.—If it could be conclusively proven that sodium chloride alone could alleviate the condition of salt starvation or the pangs of salt craving, a telling point would be made. An extract from a report by S. M. Babcock[6] is interesting in this connection. "In one case, potassium chloride instead of sodium chloride, or common salt, was given to a cow that had reached a condition of collapse through lack of salt, and considerable of it was eaten, although ordinarily cows refuse to touch it; recovery followed as quickly as when salt was given, indicating that chlorine is the only constituent supplied by salt that is essential to the health of the animal." This is at absolute variance with the theory advanced by Bunge.

Causes of Salt Craving

As stated previously, some authors have suggested as "other causes" the factors presented below, but none have attempted to compile the evidence in favor of these explanations as opposed to the older theory. The attempt here will be merely to point out the harmony between these explanations and the known facts.

1. Chlorides and Acidity.—The fact that the taste of a salt is dependent upon the cation focuses the attention immediately. Chlorides have a salty taste and the sodium combination happens to be the most agreeable one, those of higher molecular weight being more bitter. Vegetables, comparatively low in chlorides, are potentially basic,[7] as also are fruits. Meats, which are relatively high in chlorides are potentially acidic and unless cooking has removed the soluble salts, need no condiment. The addition of a neutral salt, sodium chloride, naturally does not change the potential basicity or acidity of a food, but it does increase the concentration of the Cl ions, which is the factor in producing a salty taste.

An examination of tables giving the composition of foods and whether they are potentially basic or acidic will tend to confirm this viewpoint. Those foods which actually have the highest relative quantities of chloride do not cause salt craving. Meats, fish, and cereals are decidedly acidic, while the vegetables and fruits are basic. Bunge points out that salt is not necessary upon a rice diet, and this food is potentially acidic. Other investigators were puzzled by the low amounts of salt consumed by animals fed upon oats, wheat, and corn as compared to those fed upon a mixed diet. (All cases of foods of herbivorous animals and yet not causing salt craving.) Again the fact that the grains are potentially acidic explains this, while the need for more salt on the mixed diet could be ascribed to the roughage.

No one doubts but that mineral salts are necessary, or that sodium chloride does fill a need. If this effect is not due specifically to sodium, the alternative is obvious. Fasting experiments show that the excretion

of chlorides reaches a constant level. The hydrochloric acid of the digestive juices demands the ingestion of chlorides. Animals that ingest, continually, food that is potentially basic will naturally crave a substance that can supply strong acid ions, for the body fluids function properly within a small margin of neutrality.

2. Water and Osmosis.—Numerous references may be found to the function of the sodium chloride of the blood in providing the proper concentration for this fluid. The maintenance of a certain osmotic pressure necessitates a balance in the relative salt and water intake, certainly within some limits, though they may be wide. If the taking of an excess of salt causes intense thirst, it is quite possible that an excess of water would produce the opposite sensation of salt craving, as the organism attempts to restore an equilibrium.

Referring again to food composition tables, it will be noted, that those foods which are relatively lowest in chlorides, fruits and vegetables are high in water content. The meats, which have relatively less water, have more chlorides (naturally in the ratio which the blood of the particular animal demanded) and these do not cause the craving as is the case with the vegetable types. These relations are hardly coincidental. Since the proper functioning of the organism depends upon favorable conditions of osmotic pressure, the concentration of salts in relation to the water in foods is important.

Conclusions

1. That common salt has been almost universally sought and used as an adjunct to the food of many animals, seems to be definitely established.

2. That this craving is manifested by the herbivora and not by the carnivora, seems also to be true, with but few exceptions.

3. That animals deprived of salt will weaken and eventually die has been shown by numerous experiments.

4. That the reason for the craving is that the high potassium content of vegetable foods gradually eliminates the sodium from the organism, has been advanced by Bunge and met with a wide acceptance.

5. That this theory cannot be true in the light of the facts given in the published observations of more recent investigators.

6. That probable factors are the chloride content and related to this, the potential acidity or basicity of the diet; and the comparative water content with its effect upon the osmotic pressure of the body fluids.

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Radio-active Leather Is Latest Device for Treatment. A new way to give radium treatments of any prescribed strength very uniformly, is to apply radio-active leather. Professor Taffarelli incorporated radium salts in tanning hides and found that the prepared skins had acquired their curative power. It is thought that they combine into a uniform compound with probably the albumens of the skins.

As the amount of radium salts can be regulated, the strength of the leather can be made as desired. The leather has the advantage over many other means of radium treatments in that it is flexible and can be applied over a large area and to any part of the body surface.—*Science Service*

Radium Destroys Danger of Leprosy Infections. The successful use of radium in the treatment of leprosy which, it is hoped, will result in the abolishment of the law of segregation that is imposed on those suffering from the dread disease, is reported by Doctors M. H. Neil and R. P. Sandidge of the Kalihi Leper Receiving Hospital at Honolulu. So far as can be discovered, this is the first use of radium in the treatment of leprosy, they state.

Following a series of experiments, the surgeons announce that in all cases treated with radium, "the leprous nodules disappeared. It is hoped that, by the use of radium, many lepers may be converted from dangerous carriers, emitting millions of bacilli from their noses, to persons not dangerous to public health and thus no longer in need of segregation," they assert.

Experiments with the radium treatment for leprosy have extended over a period of six months, the study being concentrated on the use of the element with especial reference to treatment of leprous lesions of the nose.

Seven cases having nodules in the nose were treated by the insertion of a 50-milligram tube in either nostril, alternating at intervals of from two to three weeks, exposure to the treatment being from one and a half to two and a half hours.

In all cases the nodules disappeared, it is said. In three of the cases the bacteria disappeared from the area under treatment. Other similar cases, not receiving the radium treatment, showed no change in nasal condition.

"It is the intent to extend the scope of this work to determine the permanence of its effects and the effect of clearing up the nose on the patient's general condition," the investigators conclude.—*Science Service*

LET'S BE CONSISTENT

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At the present time thousands of students are taking up the study of chemistry for the first time, and since the first impressions of a novice in many instances largely influence his subsequent interest in the science, it is of prime importance that the period during which he is getting his fundamental training be as free from confusion as possible. Frequently confusion and its resultant discouragement, especially among high-school students, may be prevented if the instructor's use of certain chemical terms from time to time during the school year will merely be consistent with the explanations he gives the first time these terms are discussed in the class. It will not do to spend an entire recitation period explaining the precise meaning of some particular term if during the remainder of the course, the instructor is going to be careless or inconsistent in his own use of the term. Probably everyone who has had the opportunity of observing the teaching of elementary chemistry by a number of different instructors has at some time or other met one who, during that portion of the course concerned with nitrogen compounds, would spend considerable time emphasizing the correct use of the term "ammonia," although a few days after completing the section his own application of the term might be inconsistent with his first explanation. Or, it may be that the instructor in question was given to the indiscriminate use of "carbon dioxide" and "carbonic acid." Another frequent source of trouble in this respect is the rather widespread custom of using "weak" and "strong" as synonyms for "dilute" and "concentrated," respectively. There is no lack of instructors who very faithfully explain to their classes the present accepted meaning of strong and weak electrolytes in the light of the ionization theory, but who, as soon as another subject is taken up, resume the old practice of misapplying "weak" and "strong." Unfortunately, many of the text-books contain the same errors.

Such inconsistencies may seem trivial, but they actually do puzzle the student. In many cases, of course, it is possible to infer from the context that an author may have meant to say "ammonium hydroxide" instead of "ammonia" or "dilute" instead of "weak." Those who commit such errors sometimes attempt to justify their act by the "You know what I mean, so what does it matter?" method. Inexperienced students cannot be expected to ponder over such inaccuracies to determine what the author probably meant. Furthermore, the method of attempting to discover what was meant by the author merely by examining the context is not always reliable. For example, the statement that a certain compound is soluble in "weak" acids ought to convey an idea which is decidedly different from the idea conveyed by the statement that the compound in question is soluble in "dilute" acids, yet if these terms are employed without

discrimination the reader has no way of knowing what is meant by the author, except by consulting works of other authors or by performing a test in the laboratory.

If the terms employed by an instructor are not always consistent with his explanations the students eventually will not know what is correct and what is incorrect. This introduces unnecessary difficulty and paves the way for discouragement so that finally the students lose interest. As instructors of chemistry our aim is not to discourage the new students, but to arouse and maintain their interest. By being consistent in our use of various chemical terms we can at least avoid one of the factors which lead toward discouragement. Besides, if we use terms having different meanings interchangeably, how can we teach that chemistry is "an exact science?"

Electric Current Now Measures Altitude. A new instrument which measures altitude electrically, and about eight times as accurately as the ordinary barometer, to a height of at least one mile, has been constructed by the French physicists, Drs. Huguenard, Magnan and Planiol, and was recently shown before the French Academy of Sciences. The apparatus is based on the fact that a heated object cools off much more quickly in dense air than in very thin air or near-vacuum, because in a near-vacuum there is very little matter to conduct or convey the heat away. The density of air depends on the altitude, so that an instrument that will measure air density will also give a measure of the altitude.

The device consists of a wire of great resistance, so that when an electric current is passed through, a high temperature can be obtained. Heat is immediately lost by radiation, convection currents in the air, and, to a certain extent, by conduction. After each of these leaks has done what it can, the temperature of the wire has reached equilibrium; and when once this balance is attained, changes in the temperature of the wire will be due to changes in the density of the surrounding air.

When the wire is made of a metal whose specific heat is known, the measure of its resistance to an electrical current can be used to determine how hot it should get; and from that the density of the surrounding atmosphere can be deduced. It is a well-known fact that the electrical resistance of the wire itself changes with the temperature. A variation in the density of the air will therefore cause a variation in the intensity of the electric current; and this fluctuation can be used to measure the altitude, since the density varies according to the distance above sea level.—*Science Service*

"The main skill and groundwork will be, to temper them such lectures and explanations upon every opportunity as may lead and draw them in willing obedience, enflamed with the study of Learning and the admiration of Virtue; stirred up with high hopes of living to be brave men and worthy Patriots, dear to God, and famous to all ages. That they may despise and scorn all their childish and ill-taught qualities, to delight in manly and liberal exercises."—MILTON: "TRACTATE ON EDUCATION"

THE LAW OF AVOGADRO

ABRAHAM HENWOOD, CENTRAL HIGH SCHOOL, PHILADELPHIA, PA.

The law of Avogadro is a fundamental principle of modern chemistry. In spite of this fact, however, it remains more or less an article of faith, to be justified by its works. While it is true that it has been amply so justified it would seem very much more satisfactory to the student if it were clearly and explicitly shown upon what firmly established laws of nature it depends and how it may be deduced from them.

Avogadro, in his classic memoir, puts it forth as an *ex cathedra* hypothesis which affords an explanation of the law of Gay Lussac on the combining volumes of gases. That chemists were not convinced of its validity is shown by the fact that forty-seven years went by before Cannizzaro's pamphlet led Lothar Meyer to say, "the scales fell from my eyes, my doubts disappeared, and a feeling of tranquil security took their place."

These considerations have led me to attempt what may be regarded as a deductive proof.

Let N be the number of molecules of a gas in the volume V; n the number of molecules in unit volume of the gas. Then we may write

$$N = nV$$

Now if N_1 molecules of a gas whose volume is V_1 interact with N_2 molecules of a second gas whose volume is V_2, we have

$$N_1 = n_1V_1$$

$$N_2 = n_2V_2$$

and by division

$$N_1/N_2 = n_1/n_2 \times V_1/V_2$$

or

$$V_1/V_2 = n_2/n_1 \times N_1/N_2.$$

If temperature and pressure be constant V_1/V_2 is a ratio whose terms are small integers (Law of Gay Lussac). Thus the hydrogen–oxygen ratio is 2/1. N_1/N_2 is also a ratio whose terms are small integers. This follows from the law of combining masses, thus: The combining mass of an element is the mass of that element which combines with (or displaces) an arbitrarily chosen fixed mass of a selected standard element, oxygen, for example. It is found by experiment that the composition of any substance can be expressed by *small integral* multiples of these combining masses of the constituent elements. Since one or more combining masses taken together constitute an atomic mass and further one or more atomic masses constitute a molecular mass, it follows, *a fortiori*, that N_1/N_2 is a ratio whose terms are small integers.

Reverting now to the equation $V_1/V_2 = n_2/n_1 \times N_1/N_2$, suppose n_1 is *not* equal to n_2. Then the result of multiplying N_1/N_2, a ratio whose terms are

small integers, by n_2/n_1 cannot give in all cases a ratio whose terms are small integers, as is required by the fact that this product is equal to V_1/V_2, a ratio whose terms are small integers. For example, suppose $n_1 = 2153 \times 10^r$, $n_2 = 1879 \times 10^r$, a possible case; and further let $N_1/N_2 = 1/2$, then $V_1/V_2 = 1879/2153 \times 1/2 = 1879/4306$ which is not a Gay-Lussac ratio. Therefore, n_1 cannot be *not* equal to n_2, *i. e.*, n_1 *is* equal to n_2 which is Avogadro's law.

It is to be noted that the law depends not on Gay-Lussac's law alone but to an equal degree on the Law of Combining Masses. This is a point that is not brought out in the text-books.

Furthermore it is evident that the law only holds exactly for ideal gases. In this respect it is on the same plane as the laws of Boyle, Charles, and Gay-Lussac.

Sandwich Man Earns Triple Salary of Scientist in France. The following advertisements appeared side by side in a leading French newspaper recently.

"Wanted—Assistant chief of hospital X-ray laboratory in Toulouse. 200 francs (a little less than $10 a month)."

"Wanted—Sandwich man to dress as Basque peasant and advertise a liqueur. 25 francs a day (nearly $30 a month)."

So far there have been no leading articles on the effect of present economic conditions on French scientific work.—*Science Service*

Sex Shown by Chemical Test. A chemical test for sex, so delicate that with a few drops of blood or of extract of plant juices, it will show whether the animal or plant is male or female, is being used at the Department of Genetics of the Carnegie Institution of Washington. The two scientists who are using it, Miss Sophia Satina and M. Demerc, state that it was originally worked out in Russia by Drs. E. O. Manoilov and O. Gruenberg, but that it has only recently become known outside of that country.

When applied to dilute solutions of animal blood, a few drops of the reagents cause the blood of male animals to lose its color, while under the same treatment the blood of female animals remains reddish violet.

The original discoverer, Dr. Manoilov, believed that the reaction depended on differences between the hemoglobin, or red coloring matter, in the blood of male and female animals. In order to see whether this theory also applied to the green coloring matter in plants, which is chemically similar to hemoglobin, the experimenters tried it on plant solutions. They found that the green coloring matter apparently has nothing to do with the reaction, though the plant extracts responded to the tests as definitely as did animal blood.

Whatever the unknown basis of sex may be, it is apparently the same throughout the whole range of the plant and animal kingdoms, for the test has been applied with success to the determination of sex in such diverse forms of life as mice, sheep, pigeons, fruit-flies, sea-weed, willows, poplars, hemp, begonia, and a number of other plants.—*Science Service*

To business that we love we rise betime,
And go to 't with delight.—SHAKESPEARE

Correspondence

"MOURNFUL NUMBERS"

I have been much interested in the article, by Prof. Jordy on "Mournful Numbers," and I am simply making the comment that it is possible to so successfully camouflage any simple arithmetical problem that a great majority of students will fail to see the point.

I think the first problem given in this article can certainly be classed as such.

A number of years ago Prof. Alexander Smith, speaking in Rochester, referred to the fact that students often were floored by problems because of the words rather than because of the arithmetical calculation involved. He gave as an example in "biological" arithmetic the following: "If there are more cows in the world than there are hairs on any cow's tail, then there must be two cows in the world with the same number of hairs on their tails."

The article referred to above has called forth an "effervescence" from a member of my staff. I am enclosing it for your interest. Perhaps some of us can read a message between the lines.

HARRY A. CARPENTER

WEST HIGH SCHOOL, ROCHESTER, N. Y.

Professor Carpenter's enclosure follows:

"MOURNFUL NUMBERS"

Tell me not by "Mournful Numbers"
Students' brains are but a dream;
'Tis the pedagogue who slumbers
And things are not what they seem.

Science is no Chinese puzzle—
Problems hidden in the fog
Of obscure and useless wording
By a thoughtless pedagogue.

Wake, then, pedagogues who slumber
With false nightmares of despair,
Seek within yourself the causes—
Perchance you may find them there.

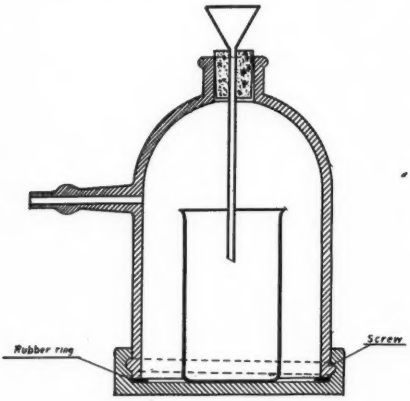
Waken, for your students, seeking
Far beyond your wordy fog
May be finding more of science
Than their slumbering pedagogue.

Waken from your dreams of anguish;
Recognize the signs of gain.
Let not your own cloudy vision
Hide from you the student's brain.

ADAIR WELLINGTON

A Convenient Suction Pump

In using a suction pump, where it is desired to preserve the filtrate, I have been impressed with the desirability of some improvements on the usual flask apparatus and so have devised the filter depicted in the accompanying sketch.



It has the following advantages:

1. A number of different solutions can be filtered without the necessity of cleaning the pump by simply substituting different beakers.
2. A small quantity of liquid can be filtered with no loss whatever by placing a beaker and test tube under the funnel.
3. There is practically no soiling of the pump. When necessary, cleaning is very easily accomplished.

The base of the jar is screwed on in much the same manner as the cover of a fruit jar, a sealed joint being obtained by means of a rubber gasket.

F. EARLE MOCK

AKRON, OHIO

EDUCATING THE PUBLIC IN WEIGHTS AND MEASURES

(Editor's Note).—This Journal is, both on its own responsibility and as an official organ of the Division of Chemical Education of the American Chemical Society, committed to the furtherance of the metric campaign. Consistent with our belief in the desirability of a full and open discussion of all controversial matters, however, we present the following comment from Mr. Dale.

In the July issue of the JOURNAL OF CHEMICAL EDUCATION,* Harvey A. Neville states that "the world is mostly metric." Before the World War, which has placed the English system still farther in the lead, a grouping of all countries according to their predominant systems of measurement gave these results:

* "Educating the Public in the Use of the Metric System," THIS JOURNAL, 2, 593–9 (1925).

	English	Metric	Local
Population	674,857,000	358,331,000	514,580,000
Area (sq. miles)	21,215,740	7,531,099	9,930,507
Wealth	$490,000,000,000	$310,000,000,000	(no data)
Income	$70,000,000,000	$24,000,000,000	(no data)

The "metric advance" is represented in the July article by a chart in which the same value is given to each country in a so-called metric group that includes the Belgian Congo, Haiti, Honduras, Siam, Montenegro, Salvador, Monaco, and Luxemburg, as is given to the whole British Commonwealth or to the United States. The misleading character of such an exhibit is illustrated by the Western Hemisphere, composed of the English group, Canada, and the United States, and twenty other countries that Mr. Neville classes as metric, but which are involved in a chaotic mixture of Spanish, metric, and English measures.

The two English countries represent 48% of the population, 57% of the area, 77% of the government revenue, 59% of the imports, 64% of the exports, 93% of the developed water power, 81% of the railway mileage, 97% of the telephones, 38% of the wool clip, 95% of the cotton crop, 69% of the copper production and 99% of the coal production of the entire hemisphere, with an annual output of $66,700,000,000 of manufactured products, the manufacturing industries of the other American countries being so small and lacking in organization that no figures are obtainable.

Mr. Neville on the first page of his article asserts that "we have weights and measures officially defined by the Bureau of Standards in metric terms," but the fact is, as Mr. Neville admits on the next to the last page, that the power to fix the standard of weights and measures belongs to Congress. Under the common law the fundamental standards of the United States are English, Congress having expressly confirmed this status by the law of 1866 which defined the metric units in terms of the English system. Hence any definition of the United States yard and pound that differs from the English standards in any conceivable degree is of no effect, and any attempt by an official of the United States to make it effective is a neglect of duty and in violation of both the constitution and statute law.

The only material divergence in British and American practice is in the use of a gallon of 10 pounds of water in Britain and one of $8^1/_3$ pounds in the United States, that is, 10 gallons to 100 pounds in Britain and 12 gallons to 100 pounds in the United States. On this comparatively trifling divergence Mr. Neville bases the claim that Britain and the United States "do not have a system in common."

Mr. Neville's claims as to the confusion caused by the avoirdupois and troy pounds and by the dry and liquid quarts have their chief foundation in metric imagination, as everyone accustomed to the use of our weights and measures knows. Regardless, however, of the extent of this diversity, the remedy consists in subtraction. It would be aggravated by addition. We have two kinds of quarts. What we need is one less, not one more, the liter. We have two kinds of tons. What we need is one less, not one more, the metric tonneau.

Mr. Neville's claim that there are 130 kinds of bushels is misleading. There is only one capacity bushel in the United States, that of 2150.4 cubic inches. In the natural change from capacity to weight many farm products are measured by units of a certain number of pounds, these "weight-bushels" being approximations of the weights of the respective products per bushel. These variations will continue until nature produces all farm products of the same weights per cubic foot, regardless of whether the weight is stated in pounds or kilograms. The situation would be made worse, not better, by calling a 60-pound "bushel" of potatoes, 27.3 kilograms, or a 30-pound "bushel" of onion sets, 13.6 kilograms. The remedy consists in hastening the natural

development by measuring these farm products by weight, say 100-lb. centals, as California and other progressive States have already done.

Mr. Neville finds in arithmetic, tables of English weights and measures that "few care to remember for long," that is, tables of obsolete or obsolescent units. The remedy for this consists in subtraction, retaining only the weights and measures in general use. The National Education Association recently recommended that this remedy be applied by taking the teaching of the metric system out of the schools.

Mr. Neville places great reliance on the power of the schools to make this country metric. That is what the metricites counted on sixty years ago when the metric system was made permissive, and the result has been failure.

All that Mr. Neville claims under the head of "Ease of Metric Calculation" is equally true of the English system, with which decimals or other fractions are used to suit the work in hand.

Mr. Neville's claim of "the entire absence of any relation (between cubic content and weight of water) among our present units" indicates that he is not familiar with the fact that 1 cubic foot of fresh water weighs 1000 ounces, that 1 cubic inch weighs 1000 quarter-grains, that 32 cubic feet weighs 2000 pounds, that 35 cubic feet of salt water weighs 2240 pounds, and that 12 gallons of fresh water weighs 100 pounds. If Mr. Neville and other bright men among the chemists of the country will detach themselves from their metric prepossessions and utilize the inter-relations that the English system offers, they will recognize that if the weights and measures of the chemical laboratory must be made to conform to those of the country, this result can be easily accomplished by changing to the English system the few units in the laboratory, leaving the innumerable standards of the industries, trades, arts, and handicrafts of the United States on their fundamental English basis.

In the face of the chaos in French textile industries at the end of 133 years, and the confusion in South America at the end of 75 years of metric compulsion, Mr. Neville still refers to a gradual change of the weights and measures of the United States in 8 years.

Mr. Neville states that "the so-called English system is a German invention." The truth is that our English weights and measures originated by natural selection in prehistoric times and their development can be traced through the standards of Egypt, Greece, Rome, and Mediaeval Europe to the present time. He also says that "the metric system is English not French in origin," because "James Watt, the English scientist and engineer, originated and first published the decimal system of measurement." It is astounding that this statement, which has been spread broadcast for six years by the World Trade Club, should have deceived Mr. Neville, for the truth, well-known to every one with an ordinary acquaintance with the history of mathematics, must certainly be on record at the University of Illinois.

The decimal notation was brought to Europe about 1200 A.D. by Leonardo di Pisa, and rapidly adopted for both calculating and measuring. Its application to weights and measures is shown by the arithmetics of the 16th, 17th, and 18th centuries. I will give one extract from *Arithmeticae Theoria et Praxis* by Prof. Andrea Tacquet, published at Antwerp in 1665, seventy-one years before James Watt was born and 118 years before Watt proposed a decimal system of measures based on the English foot and avoirdupois ounce:

> *Usus Decimalium numerorum. Mensurae and pondera dividantur in 10, partes acquales, and singulae decimae rursum in alias aequales 10, quae iam erunt centisaemae totius: Atque harum singulae iterum in 10, quae proinde iam erunt millesimae totius.*

Now as to the origin of the correlation between the English cubic foot and weight

of water. The Roman cubic foot or *amphora* of water weighed 80 Roman 12-ounce pounds or 960 Roman ounces, the Roman ounce being equal to 437 English grains as compared with our avoirdupois ounce of 437½ grains, the Roman foot being 11.64 inches. In 1685, fifty-one years before James Watt's birth, "some Gentlemen of Oxford," to quote the old English record, "determined the weight of a cubic foot of spring water, or 1728 solid inches, to be 1000 ounces averdepois." Here we see that the English foot and ounce and their interrelation with the weight of water were derived from ancient Rome.

Although the French scientists in 1790 were forced by the leaders of the Revolution to make the metric standards different from any and every standard of the past, they retained the inter-relation between cubic content and weight of water which had been developed by natural selection through the ages, but, so far as I can learn, they said nothing about the ancient origin of this feature, which has since been misrepresented as one of the distinctive and exclusive merits of metric measures.

The truth, quite different from what Mr. Neville has been led to believe, is that the English system is derived from Egypt, Greece, and Rome, while all of the metric system except the inter-relation between cubic content and weight of water, is the conception of French scientists working under the orders of men whose hands were red with the blood of the French Revolution and who rejected some of the sensible recommendations of the scientists, an everyday nomenclature for example, and compelled the adoption of the ridiculous names that now afflict users of this system.

Compare these truths about the development of the English and metric system with the errors into which Mr. Neville has been led, and one can understand that, while the broadcasting of the errors from San Francisco may be passed off as a phase of fantastic propaganda, their appearance backed by the prestige of the University of the great State of Illinois, is calculated to arouse deep indignation.

For nearly sixty years the use of the metric system has been legally permissive. Anyone is at liberty to use it who wants to. Any additional metric legislation now means compulsion. I have no fears of the result if the question of forcing the metric system into use is settled in the light of the truth. What I most earnestly protest against is its settlement by the American people in the darkness of ignorance.

SAMUEL S. DALE, Boston, Mass.

PROMOTING THE ESSAY CONTEST

Given a good excuse to deviate occasionally from atomic weights, the high-school chemistry teacher and his classes can get a surprisingly large amount of genuine enjoyment out of chemistry. The American Chemical Society's Prize Essay Contest offers such an excuse. It has been utilized at Central High School at Scranton, Pa., as an incentive for approaching chemistry as a force in civilization, rather than as a subject in a curriculum.

Among the steps taken, directly in connection with the conducting of the contest, are:

Posters secured from the Committee on Prize Essays are displayed on bulletin boards in the corridors and class-rooms (shifted from time to time), during several months.

Pamphlets from the Committee are distributed to all students in the chemistry classes, and to pupils in the upper classes not enrolled in chemistry (through coöperation with the head of the English department).

In each chemistry section, pamphlets announcing the 1923–24 contest, which have

been kept on hand, are distributed during a class period. The students read the "Treasure Hunting" article, have a class discussion on it, and return pamphlets for future use.

Pupils are told that they do not have to write essays; that the contest offers not a task but an opportunity. They are urged to do reference reading on one or more of the essay topics, whether they finally decide to write essays or not.

By arrangement with the English department, students may use one of the essay topics in chemistry for credit in their work in English composition, whether or not the essay is submitted in the contest.

Any who write essays on the required topics are also excused from giving oral reports in chemistry classes on collateral readings, which constitute part of the regular class work each semester.

In the school library, a table is set apart on which all the library's books on chemistry are kept, including duplicate copies of those provided by the Prize Essay Committee. Current science magazines are also on file. The bibliography suggested by the Committee is used as a guide in ordering new books on chemistry for the library. Books may be withdrawn from the library over week-ends, with the approval of the instructor. Pupils use the library after school hours, and with the instructor's approval during study periods.

A table is also set apart in the city library, on which are kept all of the library's books which deal with the Essay Contest topics. These are for two months considered as reference books, withdrawn from general circulation.

Books not otherwise available are loaned by the instructor to those at work on essays.

No help is given contestants beyond that of making adequate reference material easily available. (To facilitate the finding of material, students themselves have made an index of all chapter headings in the school library's chemistry books, and of articles in magazines and in Dr. Slosson's weekly Science News Letter.)

Some of the usual chemistry class procedures at Scranton High School, not directly connected with the conducting of the contest, but which do much to stimulate interest in it, include: Posting, on class-room bulletin boards current news items and pictures on applied chemistry; presenting a program at a school assembly in the auditorium once each semester by members of chemistry classes; giving an oral report to the class each semester by each pupil on a topic in popular chemistry; taking class trips to Scranton industries using chemical processes; and showing motion pictures weekly in the school auditorium during school hours (generally to science classes and occasionally to the whole school), many of which depict industrial applications of chemistry. (Scranton Central High School will exchange names and sources of such films with other schools using the screen in chemistry classes. It may be possible to keep a cumulative list of films touching on the Essay Contest topics.)

CENTRAL HIGH SCHOOL, SCRANTON, PA. L. PAUL MILLER

EDUCATIONAL FILMS AVAILABLE

The Bureau of Mines of the Department of the Interior has issued a small pamphlet entitled "Descriptive List of Motion Picture Films and Plan of Distribution." In coöperation with the mining and metal-using industries they have prepared nearly a million and half feet of film which is distributed for educational purposes under the direction of R. A. Wood at the Pittsburgh Experiment Station, Bureau of Mines, Pittsburgh, Pa.

SELECTION OF CHIEF FOR CHEMISTRY DIVISION OF U. S. BUREAU OF STANDARDS

The United States Civil Service Commission states that the position of chief of the Chemistry Division of the Bureau of Standards of the Department of Commerce is vacant, and that, in view of the importance of the position in the whole field of chemical research, and to insure the appointment of a thoroughly qualified man for the work, an unusual method of competition will be followed to fill the vacancy. Instead of the usual form of civil service examination, the qualifications of candidates will be passed upon by a special board of examiners, composed of Dr. George K. Burgess, Director of the Bureau of Standards; Dr. F. G. Cottrell, Director of the Fixed Nitrogen Research Laboratory of the Department of Agriculture; Dr. W. A. Noyes, Dean of Chemistry of the University of Illinois; Dr. W. R. Whitney, Chief of the Research Laboratory of the General Electric Company, and Mr. Frederick W. Brown, Examiner of the United States Civil Service Commission. For the purposes of this examination all of these men will be examiners of the Civil Service Commission.

The examination will consist solely of a consideration of qualifications by this special board. The minimum qualifications for consideration are a Doctor's degree in chemistry from a college or university of recognized standing, and at least ten years' experience in the direction and performance of chemical research of a character to show the required degree of chemical knowledge and ability, executive capacity of the highest order, thorough familiarity with chemical literature, and scientific maturity.

The duties of the position are to act as the scientific and administrative head of the Chemistry Division of the Bureau of Standards; to determine and execute the policies of the Bureau relating to work in chemistry; to be responsible for the maintenance and operation of the division; to direct or to perform research in the field of chemistry; and to prepare reports and data for publication. These duties involve high administrative responsibility, contact with the chemical industry and with the technical experts in the field of chemistry, and particularly the ability to plan, direct, and coördinate research, investigation, and testing of the most advanced character. In view of the close relation between the Bureau of Standards and private industry, there is no more important position in the field of chemistry in the United States than this. The opportunities for research and development are practically unlimited, and the laboratory equipment and other facilities are unexcelled anywhere in the world.

The entrance salary for this position is $5200 a year. Promotion may be made without change in assignment up to $6000 a year. The present director of the Bureau of Standards was advanced through promotion from the $6000 grade.

Qualified persons who wish to be considered for this vacancy should apply to the United States Civil Service Commission, Washington, D. C., for Form 2118, which must be executed and returned, with a list of the applicant's technical publications and reprints of such of these publications as are available to the office of the Civil Service Commission at Washington not later than Saturday, December 5, 1925.

If I may speak of the objects I have had more or less definitely in view, they are briefly these: To promote the increase of natural knowledge and to forward the application of scientific methods to all the problems of life, to the best of my ability, in the conviction, which has grown up with my growth, and strengthened with my strength, that there is no alleviation of the sufferings of mankind except veracity of thought and action, and the make-believe with which pious hands have hidden its uglier features has been stripped off.—HUXLEY

Chemical Digest

EDUCATIONAL WEAVING

The art of weaving as a metaphor for any constructive piece of work has long since become trite, but one is forced to recognize the plausibility of the term. W. W. Vaughan[1] uses it thus: "In the factory the loom stands as the essential machine for the creation of the stuff that is to clothe or adorn. In life the school stands for the fashioning of the fabric of character. The lengthwise threads of the warp must be crossed by the threads of the weft, or woof, before feeble isolation can become compact and serviceable texture. . . . Supposing that the warp represents in education the influences that shape the child's destiny as imagined by the State or the parent, now enlarging, now cramping in their effect; the cross-threads are those the teacher with skilful or clumsy hand, as the case may be, shoots, with the help of the shuttle, across the warp."

Even as the original hand loom has been supplanted by many new devices, the educational loom has been changed; the three R's have been replaced by more complicated programs which have often been the outgrowth of momentary needs. ". . . There is hardly more difference between the mat on which the half-civilized man knelt to pray and the varied and extensive products of modern cloth and ribbon looms than there is between the program of an elementary school a hundred years ago and what the children learn today. And yet, as I have said, chance, or caprice, or sentiment has had more to do with its development than any clear idea in men's minds as to what should be meant by education. At one time we have talked of educational ladders, at another of broad highways; but such blessed and consoling phrases, though possibly politically fruitful, have been certainly educationally barren. The ladders have too often only enabled the pupils to climb to narrow but overcrowded platforms, and, though on the broad highways progress has been pleasant enough, the travelers along them have at last been brought face to face with the precipice of unemployment, or have been led from the toil that wrings the sweat from the brow in factory or field to the toil that curves man's back on the office-stool or by the counter-side."

It is of primary importance that the warp be so constituted as to admit of a pattern of creditable character being woven upon it. Thus, do we not attempt to develop the intellectual ability of *all* to too great an extent? What is the measure of education? Mr. Vaughan says:

[1] "The Warp and the Woof in Education," *J. Educ. and Sch. World*, **57**, 597–602 (1925).

"The agricultural laborer, with his knowledge of and often tender sympathy with animal life, his watchings of the seasons, his weather lore, his skill, his beautiful skill, in building or thatching the rick, his power to drive a straight line with the plough, his ability by wise, almost ruthless, severity to fortify the quickest hedge, is a better-educated man, even though he left the school-room at thirteen, than many a clerk who suffered complete immersion in a secondary-school course, and, satisfied with the benefits of his baptism, has since then only become a little more skilled in figures and filing."

Whereas educational courses are designed toward vocational ends, might not the inspiration in that direction be given by the teacher or woof rather than the warp? "We need to teach more convincingly how to break the spell of gold, how to measure happiness not by 'the purple of great place' but by some other standard, how to sail past seductive prosperity, not with hands tied nor with ears stopped up with wax as Ulysses coasted the dangerous shore, but unfettered, and even attentive to choose a glimpse of truth, a love of beauty, in preference to worldly or material success. This, after all, is the power that Plato would have education produce.

"If it is on the warp that depends the plan of education, if it is in the warp that extent of opportunities, the aspiration of the community or the parent, find expression, sometimes thoughtless, sometimes mistaken expression, it is on the woof that the pattern depends, the texture, the durability, the possibilities, the charm of the fabric, or the human character. And the woof is the teacher's opportunity. If he is wise he will recognize that each individual has not the same aptitudes; if he is wiser still he will refrain from labeling one set of aptitudes as good, another as bad.

"The teacher has no sensitive weaver's finger, no miller's golden thumb, by which he can infallibly test his judgment, and yet the shuttle must fly back and forth, because if the teacher rests, the threads will soon be tangled; and even when he works there are other workers too, some deliberately, with Penelope-like perversity, unraveling by night the labor of the day, others bringing confusion into the pattern by adding threads of strange colors and uncertain strength. Because teachers feel this they often occupy the whole of a child's leisure and endeavor to monopolize its mental activities."

The task of the teacher is truly one of great possibilities, for it is to him that we must look for broader educational development. W. R. W.

Educate more for individuality, for character, and not for mere scholarship.—JOHN BURROUGHS

DOES EDUCATION MAKE THE MAN?

What can education do for the individual? The question has been variously answered. Some say, "Everything;" others, "Nothing." Both answers are given with great finality. George Boas[1] of Johns Hopkins University, however, considers a third possibility. In response to such definite statements of the situation, he says, "Curiously enough, the answer given seems to depend not so much on the actual results of education as upon a supposed theory of biology, either that the individual is the product of environmental elements, in which case the educationalist is jubilant, or that the individual is the sum of inherited traits, in which case the educationalist laments." The third possibility, as he states it, is "that education can do something for some people and nothing for other people. It is based on the theory that education is not merely an environment to which the individual reacts, but is the total interaction of the individual and the environment. . . . . For it will be found, I believe, that in learning anything an individual modifies what he learns just as what he learns modifies him. It will be found that there is a current flowing in both directions at the same time, one towards the individual and one away from him, and that he has, to repeat, as much influence upon his education as his education has upon him." He adds, "If the individual comes into the world wise or stupid, active or passive, extrovert or introvert, hyperkinetic or hypokinetic, to use even more fashionable terms, and always stays so, the only education which will do him any good is one fitted to his peculiar character. The same education for all then becomes futile and may just as well be abandoned."

Often students and teachers coöperate in the endeavor to defeat the ends of education, according to Mr. Boas. "It might not be amiss at this point to invite attention to the efforts made by undergraduates to avoid an education, an effort which has been crystallized into a tradition at some colleges, into a tradition which only the most anti-social students would dream of violating. A student may, for instance, be highly curious, he may need information about something, but he would go to the stake rather than interview his instructor about it. For if he were known to have been alone with the instructor on his own initiative, he would be instantly labelled a 'handshaker'—conduct unbecoming an officer and a gentleman. . . . There are also efforts made by teachers and administrators to prevent a student's getting an education. There is the lecture system, putting a premium on memory, the Ph.D. system, putting a premium on 'scholarship,' the text-book system, putting a premium on authoritarianism. . . . .One can see that even the serious student has difficulties with which to grapple."

[1] "The Limits of Education," *Sch. & Soc.*, **22**, 376–81 (1925).

Not considering these obstructions, he divides students into four characteristic groups:

1. Those who are utterly unteachable;
2. Those who are teachable but do not see the relevancy of what they learn—the memorizers;
3. The teachable who see a limited relevancy;
4. The teachable who have a great power of transferring what they learn to other fields.

The first, he says, can be selected by psychological examinations; the second group "can learn anything by rote but, in their purest form, do not see its application." The third group is clever within a limited field. "In physics it sees the application of the law of the conservation of energy but does not see its possible application to psychology." The fourth group "is the most interesting and the one group which might be said to have intelligence as contrasted with what Dr. Roback and people in general call 'intellect.' . . . . This group understands your ellipses and can jump a premise without breaking its bones. At their best the members of this group are interested in ideas as such. They enjoy playing with ideas, experimenting with them to see what their implications are. They make teaching interesting and conversation a delight."

With a final quotation from Mr. Boas, this question will be left for the reader's consideration. "By steady coaching, persistent conferences, private tutoring, I have been able to keep certain students from failing in my freshman course only to have them flunk out of college because of their marks in other courses. The situation is somewhat like that of the damned and the elect, according to St. Augustine. Only God knows which is which and so the church prays for them all. We teachers have the faith that we can induce God to change His mind and so we continue to teach even after the case looks hopeless. We are a chicken-hearted race and have not the courage to let students sink or swim on their own merits. We must always be encouraging, haranguing, forbidding, demonstrating, anathematizing, pleading, as if our words were magic formulas. They are just about as potent as magic." W. R. W.

QUO VADIS?

It has been said that when the teacher reaches the point where he is assailed on all sides by queries from his students, he is becoming eminently successful in his profession. Granting this, the educationalists should feel that their efforts have not been in vain. The questions discussed in several recent articles are sufficiently arresting to cause us to

stop in our mad onward rush, long enough to ask of ourselves, "Whither goest thou," educationally?

Lettice Rathbone[1] asks, "What is this 'Education'?" In answer a simile is employed in which the child's mind is pictured as a simple crystalline formation and his outlook on life as corresponding to the facets thereof. "Placed under certain conditions of solution, a crystal is capable of growing, of adding other facets, and becoming more complicated in structure. The child's mind is similar. Every time a new fact or idea is presented to him, his outlook is slightly changed and enlarged. By addition of more 'facets,' he sees his portion of the world from different angles. Thus, though the accumulation of facts is a necessary and good thing in itself, the important thing for education is the modification of outlook that it engenders." The conclusion is that, "A general education, then, may be described as the acquirement of an all-round and well-balanced outlook. See that the central crystal structure of the child's mind is of a compact, well-ordered formation, that the many facets are clear, regular, and set at a variety of angles. His reaction to life will then be full and generous. It will be said of him on all sides: 'There goes an educated man.' "

Again we are asked "why we study." Mr. Fenneman[2] answers that, "We study to get knowledge and keep it. This is a hard saying. Amid all the wreckage of old ideas must we still cling to this plank from the ark? Have not 'educators' gone beyond the crude idea of *learning* things by study? And as for *keeping* knowledge, do not alumni always assure us that no one does this any more?" He remarks further that we get our ideas of education like all well-advertised articles, "because everybody says the same thing. . . . .It must be true; why think, and make yourself peculiar? This is the way people get the notion that, after all, we don't study in order to learn something and surely not to remember it." Yet he says, "I am not, as you observe, arguing for the utility of knowledge. Some of it may be desirable for one reason, some for another. I am merely assuming that a wise selection has been made for four years' study. Some of it should become part of your intellectual machinery, some of it may better be called furniture, and some will be pictures on the walls of the mind. All together will make up the equipment for intellectual housekeeping. If any young man or woman in college does not wish such equipment and does not care for the intellectual life, then the sooner such a so-called student gets out of the college of liberal arts, the better for the college and the better for the so-called student."

A consideration of such aspects of the subject might lead to the question, "What are the marks of an educated man?" Mr. Albert Edward

[1] *Educ. Outlook*, **77**, 369 (1925).

[2] "Why We Study," Nevin M. Fenneman, *Sch. & Soc.*, **22**, 196–201 (1925).

Wiggam in a recent article[3] enumerates and discusses ten characteristics of the well-educated man. This, in brief, is the list:

(1) He keeps his mind open on every question until the evidence is all in.

(2) He always listens to the man who knows.

(3) He never laughs at new ideas.

(4) He cross-examines his day-dreams.

(5) He knows his strong point and plays it.

(6) He knows the value of good habits and how to form them.

(7) He knows when not to think, and when to call in the expert to think for him.

(8) You can't sell him magic.

(9) He lives the forward-looking, outward-looking life.

(10) He cultivates a love for the beautiful.

W. R. W.

Digestion Makes Wood Alcohol Poisonous. It is the inherent fault of man himself if he is poisoned by wood alcohol. Dr. H. Leo, who has made a study of methyl alcohol poisoning, says that ordinary grain alcohol is more poisonous than wood alcohol to isolated cells and organs. The high toxicity of wood alcohol is due to certain chemical changes taking place in the alcohol after it is taken into the body. There it is changed into formic acid, and this is the substance that does the damage ascribed to the alcohol.

Dr. Leo tried out the effect of formic acid on dogs in the laboratory and found that the symptoms were identical with those of wood alcohol. The substance not only produces a dangerous state of acidosis, but acts as a direct poison. Large doses of sodium bicarbonate—common baking soda—had a markedly beneficial effect on the experimentally poisoned dogs.—*Science Service*

Insulin Used to Cure Sores. Insulin, the widely used remedy for diabetes, has found a use in the curing of ulcers of the superficial veins of the leg, according to a statement made before the French Academy of Science by Drs. Chabanier, Dumiere, and Levert. They first noticed that diabetes patients receiving insulin treatment did not develop certain characteristic sores due to decomposition of the excess sugar in the blood, or if these had already broken out they were speedily healed. They then decided to try the remedy on a class of afflictions not associated with diabetes, but still due to excess blood sugar. Weak injections of insulin were found to result in cures. Experiments are now under way to test its efficacy in other cases.—*Science Service*

All Nature is but art, unknown to thee
All chance, direction which thou canst not see;
All discord, harmony not understood;
All partial evil, universal good.—POPE

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[3] "Ten Marks of an Educated Man," *Am. Mag.* **100**, 11–13, etc. (July, 1925).

ABSTRACTS

Modern Foreign Language Study. H. G. DOYLE. *Sch. and Soc.*, **22**, 369–71 (1925).—Many language teachers believe that the terms "scientific German" or "scientific French" are misnomers. They say that students in the science courses should have the same instruction in second-year language work as other students. The technical or scientific vocabulary can readily be acquired later when needed. SY

A New Type of College Course. J. B. MINER. *Sch. and Soc.*, **22**, 416–22 (1925).—At the college of Arts and Sciences at the Univ. of Kentucky there is a course called "Conferences on Life Interests" for sophomores and juniors recommended by professors. The purpose is not to arrive at definite conclusions but to cultivate the art of spontaneous, serious interchange of ideas and information. The subjects are announced in advance and the students are expected to acquire knowledge on the subject and to make a careful analysis. During the discussions attention is given to methods of presentation, expression, attitude toward others, leadership, and personality. Readings are suggested. The course was considered a success. SY

The Future of Alcohol Motor Fuels. M. C. WHITAKER. *Drug and Chem. Markets*, **17**, 981–2 (1925).—During 1924, 71 million gallons of alcohol were produced in the U. S. alone. Of this only about one-fifth of one per cent was used for motor fuel. During the same period the gasoline total was 125 times that of the alcohol. In any future consideration of alcohol for motor fuels, the industrial needs for alcohol must come first; only the surplus will be diverted as a fuel. 95 per cent alcohol is not miscible with gasoline; 100 per cent alcohol is completely miscible. Composite fuels made by blending anhydrous alcohol with gasoline have proved eminently successful in tests made over a period of 8 years. The superiority of alcohol-gasoline fuels over straight gasoline is now safely established. As gasoline becomes scarce an economic balance will be reached between its price, the price of alcohol and the price of raw materials from which alcohol is produced. This will result in the extensive use of alcohol motor fuels. "The technical problems have been solved by the chemical and automotive engineers. We can accordingly deposit the 'fuel alcohol baby' upon the door-step of the economist and social reformer with full confidence that our obligation has been well performed. There are no technical difficulties remaining, either in the making of an alcohol suitable for fuel blends or in the use of fuels made therefrom. The problem is now solely one of suitable economic conditions and one of public will." BAKER

Business Scavengers. (EDITORIAL.) *Drug and Chem. Markets*, **17**, 823–4 (1925).—Almost any of the alcohol denaturants can frequently be picked up from more or less mysterious sources at figures which make no pretense of approximating the market. Through diversion of the alcohol as white or pure ethyl, these substances (diethyl phthalate, quinine, etc.), are dumped on the market for anything they will bring. "The seller of them is a bootlegger, or his agent, an out-and-out lawbreaker." The buyer is worse than a bootlegger since he not only encourages the latter but also undermines legitimate business by dealing in these illicit wares. BAKER

The Chemical Revolution. ANON. *Drug and Chem. Markets*, **17**, 905 (1925).—"Industry is sitting on the edge of a chemical volcano whose eruptions will revolutionize processes, upset markets, create new products and new uses for old products and wipe out whole branches of industry." There are three strata in every chemical process industry: at the bottom are firms struggling along with antiquated processes and outworn sales methods; above them are companies operating on the basis of *status quo*, "lacking vision of the industrial future, unwilling to spend profits for future developments;" at the top are firms who build wisely and largely for the future. They are alive to the value of research and are ready to jump into new fields as they are opened up. It is mainly upon these last-named firms that the future chemical independence of America rests. BAKER

The Scientific Method. (EDITORIAL.) H. R. SMITH. *Chem. Bull.*, **12**, 202 (1925).—Two traits are cited as in evidence in a scientific mind; curiosity, *i. e.*, "the tendency to inquire into the causes of events" and "mental inertia," or a resisting of the new, a clinging to the past. "The spirit of the true scientist blends both tendencies."

The operation of these characteristics leads to the discovery and formulation of the "laws of the universe, the expression of the existence of a God of all. In this manner the honest human mind approaches its Maker." Conflicts between scientific and religious thought are spoken of as "due to ignorance of facts." Such differences now before the public are very charitably ascribed to "those who may be well-versed in one of the two fields of thought but not in both."

After an allusion to a master industry virtually created by the scientific method,

the remark is made that "even the casual mind must admit the indebtedness of the present age to the scientific method."

The author, an educator, cannot resist moralizing: "Shall we not in chemical education emphasize this principle?" By so doing science becomes the "healing of the nations" and not a Frankenstein to be feared, as fundamentalists might have us believe.

B. CLIFFORD HENDRICKS

The Significance of Dayton. B. E. SCHAAR. *Chem. Bull.*, **12**, 195 (1925).—Characterizing the parentage of the Tennessee anti-evolution law as "ignorance, intolerance, and bigotry," managing editor, Schaar, goes on to say, "such a law is a challenge to all enlightened and scientifically trained persons of this country." He conceives its danger to be two-fold; that of a combination of church and state and the attempt "to control scientific thought by legislation."

He sees in these anti-evolution laws "but one phase of a narrow, illiberal, reactionary spirit pervading the country, which has already evidenced itself in the Eighteenth Amendment, the Ku Klux Klan, the censorship of literature and other movements of similar character." The solution of the trouble is thought to depend upon "a wider distribution of knowledge."

The fear is expressed that this spirit comes from a failure to truly *think* the matter through; a willingness to accept a "rearranging of prejudices" as a substitute for thinking.

"Only one who is ignorant of the beauty which science has to offer will say that such knowledge tends toward materialism. It is the duty of those who have been fortunate enough to see this light, particularly those who have attended our universities and colleges, to pass on the newer conceptions of science to those who have not the same opportunities. Perhaps our failure to do this very thing is one of the causes of the present situation."

However disturbing the whole affair may be, such a disturbance may not have been in vain if "action toward the greater dissemination of scientific knowledge" is stimulated.

B. CLIFFORD HENDRICKS

Bibliography of Science Teaching in Secondary Schools. EARL R. GLENN AND JOSEPHINE WALKER. *Bur. Educ., Bull.* **13**, 161 (1925).—This bibliography contains titles, authors, and dates largely from the leading educational journals.

The three parts of the bulletin are captioned: General bibliography of high-school science subjects; bibliography of the chief science subjects sub-divided into general science, biology, chemistry, and physics; and a list of periodicals with addresses.

Count reveals 4098 titles listed, which are apportioned as follows: 2110 to the general bibliography, 350 to general science, 418 to biology, 486 to chemistry, and 734 to physics. When it is recalled that the Bibliography of Science Teaching, *Bulletin* No. 1 (1911), published by the United States Bureau of Education contained only 97 titles for general science and biology against 768 in the one under review and only 70 titles for chemistry and 77 for physics, a slight measure of this bulletin's thoroughness can be inferred.

In the introductory note the statement is made: "This publication represents the first portion of the work. The preparation of a critically selected, annotated bibliography for a limited number of topics in the field of science teaching is in progress and will be published later."

B. CLIFFORD HENDRICKS

Allotropy of Zinc. W. M. PEIRCE, E. A. ANDERSON, AND P. VAN DYCK. *J. Frank. Inst.*, **200**, 349–61 (1925).—Two or more allotropic modifications of zinc are claimed by writers; but attempts to detect these by the authors have furnished only negative results. The X-ray method has proved a new and direct means to answer the problem definitely. "According to the usual conception of allotropy, as affecting the structural condition of metals, atoms of the same kind are capable of arranging themselves in more than one space lattice, and each possible arrangement is stable in a definite range of temperature different from that at which any other arrangement is stable. Such changes in the arrangement of the atoms are naturally more or less strongly reflected in changes of physical, mechanical, chemical, and electrical properties." The X-ray measures directly the spacing and arrangement of the atoms.

Reference is made to the recent papers of Losana, A. W. Hull, and R. W. G. Wyckoff. Zinc used in experiments was prepared by vacuum redistillation of zinc of 99.993 per cent purity. A detailed description of the apparatus used, the temperatures, and the names of the experimenters follows. The results are then carefully discussed and the following conclusions drawn: "(1) Zinc occurs with a hexagonal, close-packed structure, having an axial ratio 1.86. This is in close agreement with Hull's findings. (2) Within the limits of experimental error, there is no change in the X-ray diffraction

pattern of pure zinc at atmospheric pressure and between 20° and 400°C., indicating that within this temperature range zinc occurs in only one form, there being no allotropic transformation in this range." J. HOWARD GRAHAM

The Way of the Wind. W. J. HUMPHREYS. *J. Frank. Inst.*, **200**, 279–304 (1925).—The paper is theoretical and mathematical. The causes of the wind are explained. The deflective force of a moving portion of air, or the force it would exert if constrained to move in the same geographic direction is given as: (*a*) Directly proportional to its mass; (*b*) directly proportional to its horizontal velocity; (*c*) directly proportional to its angular velocity of the earth's rotation; (*d*) directly proportional to the sine of the latitude of its location; (*e*) exactly the same whatever its horizontal direction; (*f*) always at right angles to its instantaneous direction, hence without effect on its velocity; (*g*) opposite to the direction of the earth's rotation, hence to the right, or clockwise in the northern hemisphere; to the left, or counterclockwise in the southern.

"The way of the wind is devious and strange. It is not past following, but that following is exceedingly difficult, if not quite impossible, without the guidance both of sound physical concepts and accurate mathematical analysis." J. HOWARD GRAHAM

International Education Research Council and World Bureau of Education. G. W. A. LUCKEY. *Sch. and Soc.*, **22**, 121–8 (1925).—After years of critical study of national educational systems, a plan is proposed for establishing an international council. It is to be "central, coöperating, advisory, informing, investigating, and enlightening; fundamental to the existing national and international educational and research organizations; to collect, digest, preserve, and disseminate useful information on the status, nature, and progress of education among organized peoples of the world. . . .to study methods and products of education in order to discover those that make for war and those that make for peace. . . .to formulate reliable tests for accurately measuring scholarship of students who pass from country to country. . . .to become the world clearing house of the best and most accurate information available on all phases of national and international education and human welfare." A provisional plan for establishing this council is outlined. SY

Uniform Grading System. JAMES HARVEY ROGERS. *Sch. and Soc.*, **22**, 160–2 (1925).—A suggestion to standardize everybody and everything educational. "Snap" courses and their instructors to be standardized instead of eliminated. The plan suggested is a modification of one introduced by Max Meyer, in the Univ. of Missouri, 17 years ago. Meyer's system was to rate approximately one-half of class as average or medium (M), approx. one-fourth above M (S, superior, E, excellent) and one-fourth below M (I, inferior, F, fail). Only a few should get an E, and I's should be given more frequently than F's. System does not apply to small classes. But to be of real merit, a grading system must make for uniformity of grades among the different courses, and the following modification is proposed: each student is indexed according to his previous scholastic record, multiplying his E, S, and M credit hours by 2, 1.5, and 1, respectively.

$$\begin{array}{l} 3 \text{ credit hrs. E by } 2 = 6 \text{ index hrs.} \\ 8 \text{ credit hrs. S by } 1.5 = 12 \text{ index hrs.} \\ 3 \text{ credit hrs. M by } 1 = 3 \text{ index hrs.} \\ \hline 14 \text{ credit hrs.} = 21 \text{ index hrs.} \end{array}$$

$$\frac{21 \text{ index hrs.}}{14 \text{ credit hrs.}} = 1.5 = 150\% = \text{student's index.}$$

The arithmetical average of the individual indices is the index of the class. A class with many good students will have an index of over 100, a poor class will be below 100. If a class index is over 100, more marks above M, and if class index is below 100, more marks below M should be given. SY

Adjusting Marking Systems to Differences in Groups. W. F. TIDYMAN. *Sch. and Soc.*, **22**, 247–8 (1925).—The common system of marking where a certain per cent of the class gets A's, another B's, etc., does not take into consideration the fact that a class might be composed of an unusual number of superior or inferior students. The Otis Higher Examination Test was used to determine intellectual character of freshman class. The per cent of A's, B's, etc., to be given was determined by the results of the Otis Test. SY

Some Essentials in the Process of Preparing for College. OTIS E. RANDALL. *Sch. and Soc.*, **22**, 281–7 (1925).—The four-year period preceding entrance to college is important. High-school students may be trained, and usually are, to memorize enough to pass college entrance examinations before they are 18 years old. But unless

they have digested what they have memorized they are not ready for college. They need a three-fold development of the powers of mind, body, and spirit, and this should begin in high school. Before entering college, the student should have a reasonably clear notion as to the aim and object of the college curriculum. Hundreds of high- and preparatory-school graduates enter college annually who lack initiative, self-reliance, and grit. SY

Warp and Woof in Education. W. W. VAUGHAN. *Sch. and Soc.*, **22**, 313–9 (1925).—Many are not clear as to what is meant by education. Nowadays chance or caprice or sentiment has much to do with educational development. We do not train all our citizens to the limit physically although such training is desirable. Why should we attempt to do so mentally? Discontent is necessary in life, but it isn't divine when it expels all redeeming qualities and pleasures from our active life. This condition has been brought about at least in part because many continue in school too long. After the age of 14, the student who shows no aptitude for book learning should be allowed to develop his abilities in industry. Many of the latter become as truly educated as those who complete secondary or higher schooling. We need to teach the secret of getting happiness out of one's work. SY

The Superior Student in College. CHARLES F. THWING. *Sch. and Soc.*, **22**, 245–50 (1925).—A dozen or more types of methods for examining candidates for admission to the freshman class are in use today. The real problem is to find the superior student after he has entered college. The superior student should devote his energies to great subjects, to some great field of study; his work should be directed by the tutorial method; and he should have the opportunity to meet great characters who are also great teachers. In taking care of the superior student we must not neglect the common one. And we must not allow the superior one to lose himself in self-esteem and vanity. And finally we must keep before us what might be called the national mind. SY

Tests for Carbon Monoxide. (EDITORIAL.) *Chem. Age*, **13**, 243 (1925).—The value of the pyrotannic acid method for the quantitative determination of carbon monoxide in blood and air is again emphasized by the U. S. Bureau of Mines. The presence of the poison may be detected by this method much more quickly than by methods previously used. The Bureau claims that the only infallible diagnosis of carbon monoxide poisoning is made by an examination of the blood for carbon monoxide hemoglobin, the compound which the gas forms with the coloring matter of the blood. Through the formation of this compound, the hemoglobin becomes ineffective as an oxygen carrier.

Some of the previous methods for the quantitative analysis of carbon monoxide when present in the blood or air in quantities large enough to affect the health and safety of a person, were suitable as to accuracy. They all had, however, the disadvantage of requiring either elaborate or expensive apparatus, or calling for special technique or training on the part of the analyst, or were too delicate or too cumbersome for field use. The Bureau of Mines found it necessary to develop a method and apparatus which could be immediately taken to the scene of the poison and which would give accurate results as to the carbon monoxide in the blood or in the air. This method is known as the pyrotannic acid method and has been found reliable and accurate. Its simplicity and ease of operation make it well suited to the needs of hospitals and similar organizations.

Details of the pyrotannic acid method are given in *Technical Paper* **373**, a copy of which may be obtained from the Bureau of Mines, Department of Commerce, Washington, D. C. W. R. W.

Egypt, the Land of the Alchemists. A. J. HOPKINS. *Repts. New Eng. Assoc. Chem. Teachers*, **25**, 6–9 (1925).—"In Alexandria, in Egypt, two peoples were gathered together: the practical Egyptian with his love of technical skill and his devotion to hard work; and their conquerors, the Greeks—the dreamy, theory-loving Greeks. From this union of opposite natures Alchemy sprang."

The article gives the history of Alexandria. "Even after Egypt became a Roman province in 30 B. C., this 'Queen city of the Mediterranean' for four centuries more—until the rise of Constantinople—was the most noted city in intellectual activity of the early centuries of our era. Here began militant Christianity and here also Alchemy was born."

The theories of alchemy are also touched upon. The Greek theory described is mentioned as being inherited by the alchemists and not as being their invention. In 292 A. D. alchemy was driven out of Egypt by a decree of Diocletian and thereafter it established itself in western Europe. The definition of gold, however, had changed in the thousand years intervening to our modern definition. The author concludes the article with a paragraph on the present conditions in Egypt. W. R. W.

Absorption Spectra and Chemical Constitution. E. C. C. BALY. *Rice Inst. Pamphlet*, **12**, 1–34 (1925).—A lecture and resumé of some of B.'s work together with a historical outline of the relation between absorption spectra and chemical constitution. Various theories are discussed and criticised.

Fluorescence and phosphorescence are closely related to absorption spectra. Many substances exhibit different absorption bands under conditions provoked by changes in solvent or in temperature. Substances may also exhibit two and three absorption bands under the same conditions.

The extinction coefficient plotted against the wave lengths shows that the absorption band has a measurable breadth but there is one frequency, the central frequency, for which the absorptive power is a maximum. There is a constant difference between the central frequencies characteristic of a given compound. The different absorption bands must be due to different physical states of the same molecule and not to variation in structural modifications. The relation of Planck's theory to absorption spectra is emphasized. T. G. T.

Universities as Centers of Chemical Research. (EDITORIAL.) *Nature*, **116**, 193–5 (1925).—A discussion of Prof. W. P. Wynne's presidential address to the Chemical Society. A lack of sufficient funds is responsible for most of the present day defects and deficiencies of chemical research in the universities. The significance of W.'s detailed figures must not be over-estimated; it may be doubted whether numbers of papers published can afford an unambiguous index of research activity, and also the statistical method used takes no cognizance of quality. Manufacturers still complain of the inefficiency, from the works point of view, of the university-trained man, but are the universities entirely to blame? What opportunities do industrial firms offer the student for testing his vocation while there is yet time for him to make another choice? Is it not possible to allow selected students to spend some part of each long vacation in the works, not necessarily in the laboratory, but under foremen on the plant? The common objections have been overcome in Sheffield and the example should be followed in other centers and in other industries. H. K. M.

The Isotopes of Mercury. F. W. ASTON. *Nature*, **116**, 208 (1925).—A. has built a mass spectrograph giving double the dispersion of the one previously used. Preliminary photographs of the mass spectra of mercury show its lines clearly resolved and so enable a definite statement to be made on the mass numbers of its most important constituents. There are six: 198[4], 199[5], 200[7], 201[3], 202[10], 204[2]. The numbers in brackets indicate very roughly the relative intensity of the lines and, if the whole number rule is assumed to be exact, correspond to an atomic weight in agreement with the accepted chemical one 200.60.

These results have a direct bearing on the claims recently made that under special conditions mercury has been transmuted into gold by the addition of an electron to the nucleus. It is clear that if gold is so formed it should have an atomic weight at least as high as 198, that is, perceptibly higher than that of ordinary gold 197.2. A definite determination on this point would seem to provide conclusive evidence on this interesting problem. H. K. M.

The Crystalline Structure of Inorganic Salts. W. L. BRAGG. *Nature*, **116**, 249–51 (1925).—The organic crystal appears to be composed of definite molecules. Inside each molecule the atoms are bound together by forces so local, and so rigid, that an addition to one part of the molecule scarcely affects the rest; these molecules are then massed together by comparatively weak forces into a crystalline structure. The form of the inorganic crystal suggests that the bonds between atom and atom are not limited to certain directions; the molecule is more fluid and an addition to one part profoundly disturbs the relationship of all the rest. The inorganic salts can be analysed more completely than organic compounds. The number of atoms is generally smaller and owing to the power of readjustment, the atoms often take up a symmetrical arrangement and this symmetry makes the X-ray investigation more easy. In inorganic crystals it is often easy to replace one atom by another of similar chemical properties without altering the crystalline structure. The heavier atoms scatter X-rays more than the lighter ones and it is an easy matter to fix the position of the metal atom of high atomic weight, and so with the heavy atom of the acid radical. The exact dimensions of the electronic orbits are not known and, although the atomic domain is quite elastic, a study of these radii is one of the principal aids in tackling a difficult crystal structure. Cases where the domain of one ion is much larger than that of the other are especially interesting. In alumina, for example, since the oxygen ion is so much larger than the aluminum ion, the structure is that of a series of oxygens in a close-packed arrangement (hexagonal) with aluminum atoms in the interstices acting as a cement to bind the whole together.

In a few cases it has been possible to determine the shape of the acid radical. In CO_3^{--} and NO_3^- the oxygen atoms are arranged at the corners of an equilateral triangle around the central atom. Though the arrangement of the oxygen atoms round the sulfur atom in SO_4^{--} is not known with such certainty, they must be nearly at the corners of a regular tetrahedron. In $PtCl_6^{--}$ Wyckoff has shown that the six chlorine atoms are arranged at the corners of a regular octahedron around the platinum atom. X-rays can only tell the positions of the atomic centers, the skeleton of the structure since the interference between waves scattered by the electrons is so complex. H. K. M.

Catalysis and Oxidation. H. E. ARMSTRONG. *Nature*, **116**, 294–7 (1925).—A. urges that the term catalysis be limited to actions *at* and *influenced by solid surfaces*. Chemical change is an electrolytic process. On this assumption, while electrolytes, in solution, may interact directly, chemical action between non-electrolytes is an indirect process determined by the presence of an electrolyte compatible with the substances ultimately brought into interaction through its agency because of its power of linking them in a conducting circuit. Many examples are given to illustrate and support the theory. H. K. M.

Transformation of Mercury into Gold. A. S. RUSSELL. *Nature*, **116**, 312 (1925).—The possibility of the transformation of a nucleus into that of the element next below it by the absorption of one electron is most likely to be detected when both nuclei are stable. This occurs most obviously when the elements have a mass in common, an isobare of odd mass-number. We have no direct experimental evidence of the existence of isobares of odd mass-number among the non-radioactive elements but there are two cases where the possibility of their existence may be inferred from experimental work. The existence of the thallium isotope 205 is probable from F. W. Aston's general results for elements of odd atomic numbers and the value 204.4 for the atomic weight. Reasons for the lead isotope, 205, are given in *Phil. Mag.*, **48**, 365 (1924). From atomic weight of gold 197.2 it may be inferred that this element has isotopes 197 and 199; mercury, as F. W. Aston has shown, has the isotope 199. It is suggested that the transformation of lead into thallium is as possible as that of mercury into gold. H. K. M.

Mosely's Work on X-Rays. ERNEST RUTHERFORD. *Nature*, **116**, 316–7 (1925).—A brief review of M.'s researches and the announcement that a negative of M., taken probably in the Balliol-Lincoln Laboratories at Oxford in the summer of 1910, has been sent to R. by Mr. N. G. Thomas and that enlargements are now available. It had always been a matter of regret that no reasonable portrait of M. could be found. H. K. M.

The Future Science of the Schools. C. L. BRYANT, J. A. NAIRN, W. H. D. ROUSE, AND H. A. WOOTON. *J. Educ. and Sch. World*, **57**, 550–4 (1925).—Four comments on Prof. H. E. Armstrong's article (J. CHEM. EDUC., **2**, 942 (1925)), in which they criticize A. for being too despondent and hasty in his judgment of headmasters and the teaching of Latin and Greek although they admit that some of his points on science are well taken. H. K. M.

The Future Science of the Schools. W. H. F. *J. Educ. and Sch. World*. **57**, 606 (1925).—W. H. F finds much food for thought in A.'s article (see above), and most nutriment in his diatribe against examinations. H. K. M.

The Future Science of the Schools. H. E. ARMSTRONG. *J. Educ. and Sch. World*, **57**, 606–10 (1925).—Reply to the above criticisms. Polemical, but well worth reading. H. K. M.

Fused Silica. ELIHU THOMSON. *J. Frank. Inst.*, **200**, 313–25 (1925).—Refers to the work of Despretz (1849) and R. S. Hutton about twenty-five years ago. In the laboratories of the General Electric Co., clear masses are obtained from fusion in an electric vacuum furnace of properly selected and prepared rock crystal. Retained bubbles are collapsed by high pressure. Silica does not undergo limpid fusion but sublimes rapidly. A less opaque or translucent product is prepared from fairly pure siliceous sand and this serves for many purposes. As to mechanical properties, fused silica appears to be an ideal glass, brittle like ordinary glass, harder, and more perfectly elastic than glass and does not set under strain. It is a highly elastic solid and is admirably adapted to the making of tuning-forks. As to thermal properties, fused silica has an almost negligible temperature coefficient of expansion. Roughly it has about $^1/_{17}$ the expansion per degree that platinum possesses. It may not be impossible that in the future, cooking vessels may be made by the fusion of a kind of sand known as flint shot. The author believes it possible to construct pendulum rods of quartz and also balance wheels and hair springs of watches and clocks. Thermometer tubings have been made. Fused silica may find application in optical apparatus such as lenses for projecting lanterns of

moving picture houses, and for astronomical mirrors, instead of glass. The refractive index for the D-ray for fused silica is 1.459 as against 1.52 for crown glass. The property of transmission of light rays through rods of fused quartz is not peculiar to the latter. This property is possessed by certain crown glasses with rod lengths of a foot or more and by smooth streams of water. With fused silica, however, twenty-six feet of rod is no barrier to transmission. It is probable that fused silica will rank as the most transparent solid known. Heat rays are carried through the silica in a similar way. Fused silica is very transparent to the ultra-rays of the spectrum up to wave lengths of about 2000 Ångströms, hence its application as a curative "dermal" stimulus and as a germ killer. To obtain clear masses for prisms, lenses, etc., fine granular material of nearly uniform size is placed in a clear silica flask, fused in a good vacuum and then subjected to high pressure. J. HOWARD GRAHAM

The Twilight Zone of Matter. ALEXANDER FINDLAY. *Chem. Age.* **13,** 274–5, 328–9(1925).—Findlay applies the above title to the colloidal state of matter. He reviews, in his article, the work done on colloids, text-book fashion, defining adsorption and other colloidal phenomena. The precipitation of fine particles by electrolytes is illustrated by the finely divided clay carried by rivers being caused to deposit when river water mingles with the sea. This causes the silting up of river mouths and formation of deltas to take place.

The process of adsorption plays an important part in the dyeing of textiles. Where mordants are used adsorption takes place, the mordant, being a colloid, adsorbs the dye and fixes it on the fiber.

The protoplasm of the cells consists of a mixture of colloids. "In the cell, indeed, we have, as it were, a complex emulsion or mixture of colloids which, under the changing conditions of life, may vary in consistency from that of a colloidal solution to that of a colloidal gel or jelly. In this system there occur processes of adsorption, changes in dispersity, alterations of the distribution of water between the colloidal particles, and the dispersion medium. . . .The living organism, therefore, is a vast colloidal community, the diverse members of which are held together in common service by surface forces, and by the mutual actions and reactions of electrical changes, and in this community the colloidal workers are engaged in carrying out the multifarious and complex chemical operations on which the life and the health of the community depend."

The work of Bancroft and Clowes is referred to. One of the most interesting phenomena in connection with the action of electrolytes on living cells is the so-called antagonistic action of ions. The beat of the heart, continuously perfused with a solution of sodium chloride, isotonic with the blood, soon ceases, but the toxic action of the sodium ions can be counteracted by the addition of a small amount of a calcium salt. Clowes has shown that there is a very close resemblance between the effects produced in emulsions of oil and water and those produced in biological systems, and he has made the valuable suggestion that the cell membrane is a system, a colloidal emulsion of two phases—a watery solution of protein, and a lipoid phase. According to this view, one is able to explain many of the phenomena associated with the action of the cell membrane. W. R. W.

Chemicals in Food. (EDITORIAL.) *Chem. Age,* **13,** 317 (1925).—The use of boric acid as a food preservative is attacked by Mr. A. G. R. Foulerton of the Hygiene Department, London University College. He insists that boric acid is an antiseptic and not a disinfectant or germicidal drug. It inhibits the multiplication of bacteria temporarily but does not destroy them. The bacteria themselves remain alive but in an inactive or dormant state. "A sausage or pork pie, for examples, made from unsound meat which, although it contains objectionable bacteria, has not yet reached the stage of actual putrefaction, will remain inoffensive to the nose or eye if preserved with boric acid. When the food is taken into the stomach the boric acid becomes diluted, the antiseptic or inhibitory action of the drug is lost, and the hitherto dormant bacilli will resume their normal activity. All of which, if correct, is a little chilling to the appetite."

Foulerton deplores the fact that England buys boricized food. W. R. W.

Chemistry in War: An 18th Century Viewpoint. *Chem. Warfare,* **11,** 5–7 (1925).—Chemistry has been greatly credited with providing the resources of war and blamed for its horrors. As long as two hundred years ago Hermann Boerhaave, a great Dutch physician and chemist, gave it the same praise and blame. After money, Boerhaave considered chemistry the chief support of war. His particular grievance was against black powder.

Primitive men fighting with stones and clubs no doubt felt a resentment against the unsportsmanlike conduct of the first enemy who threw sharpened sticks of wood. But they rapidly adopted the use of spears, and, in due course of time, were again annoyed

by an adversary who was not content to throw his pointed sticks but shot them with greater velocity by reason of the elastic force of a bended bow. The advantage has always been with the more intelligent, and improvements in methods of warfare have been due to advances in scientific knowledge. Since the introduction of gunpowder, changes have been in the direction suggested by chemical discovery.

"Warfare becomes increasingly a matter of intelligence. While admitting the dependence of intelligence upon heredity, stimulating environment, etc., we find nevertheless that there is a chemical something without which there can be no thinking. Since the gray matter of the nerves and brain is made up of carbon compounds of phosphorus and nitrogen, it appears that without nitrogenous foods there can be no thinking; and an army thinks with its nitrogen. Whatever may have been the case in Boerhaave's day, in the present Nitrogen Age it is certainly true that 'the chief support of war must now be sought in chemistry.' It may be that chemistry is more important than money, for without nitrogen we can have no food, no powder, and even no ideas about the matter." W. R. W.

To Conserve Hydrogen Sulfide. GEO. A. HERRMANN. *Chemist-Analyst*, **45**, 19–20 (1925).—The preparation of a Kipp hydrogen sulfide generator is one of the most disagreeable tasks in laboratory work especially when a frequent renewal of the acid sulfide is necessary. The supply may be conserved by partially opening the stopcock while the generator is in use, but few college freshmen heed this precaution.

The following suggestion is offered for laboratories where a large number of students use a Kipp generator: "A piece of 6 mm. (outside diameter) glass tubing is drawn out in a capillary and is inserted in the rubber tube attached to the generator. This tubing should be of the same size as the glass tubing used for the capillary. This arrangement will allow only a limited supply of the gas to pass over, even though the stopcock is wide open. There are times when the capillary becomes clogged. In this event a new capillary can be inserted, or the clogged opening can be opened by blowing water through the glass tube."

A generator which ordinarily lasted two days was found to be of service for several weeks with this arrangement. This can also be used for other gases where a Kipp is employed. W. R. W.

The Handmaids of Medicine. LAWRENCE H. BAKER. *Atlantic Mo.*, **135**, 796–804 (1925).—The author begins with a description of the sanctuary of Asclipius at Athens as exemplifying the primitive idea of healing. This, in a sense, seems to symbolize a relationship between the spiritual and material in the successful treatment of disease. "Modern medicine," he says, "developed by the separation of fact from fancy" is the recognition of a difference between therapeutics and magic.

But "the development of magic marks a step forward in the development of medicine." Germs have been substituted for "worms and snakes;" "internal secretions" for "humors" and the Freudian theory of the unconscious for the more subtle and mystifying parts of the medicine man's treatments.

He considers the "order of succession" of medicine and her handmaids as: medicine, chemistry, physics, biology, and psychology—these are the ends, modern ends started back in the race's twilight zone of healing. "Medicine is the patriarch of the group, but a patriarch who has only recently come to mobilize the entire forces of his family in the age-old feud with disease."

In ancient Egypt, in the land of Chemi, the priests started the experimentation which became chemistry by use of substances of curative value. Later the chemist turned his knowledge more to industrial lines. "This defection has resulted in much suffering which closer coöperation between physician and chemist might have spared." It was, as an instance, five hundred years from the time that ether was discovered until it began to be used as an anaesthetic.

"Today the pharmacologist presiding over a well-supplied laboratory in an institution of research represents, perhaps, the best blend of physician and chemist. The maximum of success in the alleviation of suffering is, however, to be attained only when the pharmacologist serves as the medium between chemist and physician; when all three work in recognized interrelationship."

One modern department of medicine stands out prominently for the coöperation it has produced between chemist and physician. That is the department of gland therapy or endocrinology. Every human body is now conceived to be a chemical laboratory, in which the most complicated transformations are taking place. Every man, even in the midst of health, is a walking drug store. The impairment or inadequacy of his drug supply may result in diseases such as gout, diabetes, goiter, giantism, and insanity. Even invading disease germs accomplish their fell work in many cases

through chemical agencies, their toxins being potent drugs that act upon the heart, respiratory nerve-centers, or some other vital apparatus.

"Medicine is heavily indebted to the development of the germ theory." "Both bacteriologist and pathologist, however, have now reached a point where they must turn to chemistry for the solution of the most important of their problems. The antitoxins are chemical substances of specific curative power but of unknown composition." The development of antitoxins is a "significant example of human ingenuity in employing animals as living chemical factories but there is, at present, no way of checking up on the output of these factories."

After devoting some five pages to a very interesting treatment of the relation of physics and psychology to modern medicine, the future of medicine is suggested: "With chemistry, physics, biology, and psychology advancing as they are, and coöperating with medicine as desired, medicine must inevitably itself approach the plane of the exact sciences. But it can approach only as a variable approaches its limits."

B. CLIFFORD HENDRICKS

Paper Mill Waste Helps Clear Air. Instead of fouling streams, the waste from Swedish paper pulp mills is expected henceforth to help keep dust out of the air. Though the air in Stockholm is on the average ten times as free from dust as that of London in a heavy fog, for instance, a campaign has been started to make it as nearly dust-free as possible, and in this a valuable ally has been found in the sulfite lye which the pulp mills of Sweden have hitherto poured away as worthless waste. This summer all the macadamized or unpaved roadways and streets in Stockholm have been sprayed with the lye, to which lime water has been added to make it less soluble in rain. The city authorities of Malmoe and other places have also begun to buy the sulfite lye by the car-load to use it on the roads, and a separate company has been formed to exploit the new dust-binding material.

The measurements of dust particles in the air have been made by the meteorologists and the Swedish Government's official weatherman, Prof. Anders K. Angstrom, has calculated that on the average the air in Stockholm contains 4000 dust particles per cubic centimeter, while in London the usual figure is 10,000 and in heavy "pea soup" fogs runs up to 50,000. The number of dust particles inhaled each minute by a person walking through a London winter fog has thus been estimated at 450,000,000.

—*Science Service*

Scrap Iron and Dynamite Suggested for Frost Protection. With the coming of late fall, and the approach of colder weather, fruit growers in different parts of the country are beginning to take elaborate precautions to protect their orchards from the ravages of Jack Frost, but not all the suggestions that have been made to the Weather Bureau will be used. According to J. B. Kincer, chief of the Department of Agricultural Meteorology, a great many of the suggestions that enthusiastic inventors send in are wildly impractical.

"The 'crank' proposals," says Mr. Kincer, "range all the way from hanging pieces of scrap iron in the trees to 'absorb' the frost, to exploding dynamite in the air above the trees to break it up before it can 'fall.' Another extreme proposal was to throw cotton strings over the tops of the trees and allow the ends of the strings to dip into a pail of water to conduct the frost into the water where it could do no harm. This was actually patented!"

However, orchards can be protected from frost by tried and approved means. "The citrus growers in Florida and California have used these methods more extensively than any others," said Mr. Kincer. The most efficient devices are the oil heaters, with tall chimneys, from which a large amount of heat is radiated. Each holds about nine gallons of oil, and about fifty heaters are required to the acre for adequate protection. "In a single grove," he said, "there may be as many as 10,000 heaters and as much as $3000 worth of oil may be burned on a bad night."—*Science Service*

Local Activities and Opportunities

University of California, Southern Branch. Dr. A. L. Raymond, Ph.D., 1925, at California Institute of Technology, Pasadena, has recently been appointed half-time instructor in chemistry at the University of California, Southern Branch. Investigation of the mechanism of alcoholic fermentation is being continued by Dr. Raymond at the California Institute of Technology. This research is a development of the studies upon insulin carried out last year at the Institute under the direction of Prof. Abel.

University of Chicago. Dr. E. E. Slosson, '02, Editor, *Scientific News Service*, and author of "Creative Chemistry," gave a public lecture on "Chemistry and Human Welfare," at Orchestra Hall, Chicago, Ill., on Monday evening, November 9th, under the auspices of the University of Chicago. The lecture was preceded by a brief address by Professor Stieglitz on "The Science of Chemistry," illustrated by a few experiments.

Professor Harkins was on duty as consulting engineer of the Air Service at Dayton, Ohio, during the latter part of September.

Professor Stieglitz attended a conference of the Committee of the Public Health Service on the use of tetraethyl lead in gasoline in Washington, D. C., October sixteenth and seventeenth.

A. M. Neff, Ph.D., '25, has been appointed to a research fellowship on gelatin at the Mellon Institute of Industrial Research.

Alfred Jurist, Ph.D., '21, has accepted an appointment as research chemist with Squibb and Sons, New Brunswick, N. J.

Walter Russell, who has completed his research for the doctorate degree and expects to receive the degree at the December, 1925, convocation, has accepted a research appointment in the Agricultural College at New Brunswick, N. J. The appointment is in the department of Professor Lippmann.

Judith Wallen, M.S., '25, holds the position of research chemist with the International Filter Company of Chicago.

W. G. Guye, Ph.D., '25, is professor of chemistry at William and Mary College, Virginia.

Lyman Chalkley, Jr., Ph.D., '22, who until recently has been employed as research chemist with the Standard Oil Co. of Indiana, has accepted a research fellowship at Columbia University.

About forty-five students are engaged in Ph.D. or M.S. research work in Kent Laboratory during the present quarter. A National and an International Research Fellow as well as a Guest of the University doing independent work are also engaged in research in this laboratory.

Ralph L. Brown, Ph.D., '17, was the recipient of the Beal Medal from the American Gas Association for the best technical paper published, during the year, concerned with illuminating gas.

Columbia University. During recent months the organic laboratories of Columbia University have been fortunate in securing additional financial assistance for their research work as follows:

1. The American Manufacturers of Toilet Articles, at their recent convention in this city, April 21–23, 1925, unanimously adopted a resolution providing for the establishment of an Association Fund to be paid annually to the University for the support of pure scientific investigations in that branch of organic chemistry which concerns the perfumery and toilet goods industry, said investigations to be conducted under the direction of Professor Bogert.

2. Through the generosity of Mr.

F. A. Watermeyer, President of Fritzsche Bros., Inc., New York City, a research fund of $3000 per annum has been provided for the support of one or more research fellows to pursue investigations in the field of perfume chemistry. The Fellows for the current academic year are Dr. M. Scott Carpenter and Mr. Edmund H. Hamann.

3. The committee in charge of the research fund of the Society of Sigma Xi have made an appropriation of $500 to Professor Bogert for assistance in the prosecution of researches in the synthetic drug field and Mr. Eugene M. McColm, recently of the research laboratory of the Goodrich Company, Akron, Ohio, and now one of our graduate students, will give part of his time to this work.

4. Columbia University has provided a research assistant to aid Professor Bogert in his work in the synthetic drug field, especially in that line of investigation which has to do with the preparation of organic compounds containing both selenium and arsenic. Dr. Arthur Stull is the present incumbent of this research assistantship.

N. E. A. C. T. The New England Association of Chemistry Teachers held its annual meeting at Wheaton College, November 14th. The program was as follows:

10 A.M. Address of Welcome—Prof. George T. Smart, Acting President of Wheaton College.

10.15 A.M. Demonstration of a Simple Colorimeter—Prof. Glen A. Shook, Wheaton College.

10.30 A.M. Symposium, "The Place and Value of Tests and Examination in High-School Chemistry"—Five members of the Association.

11 A.M. Demonstration—Prof. A. L. Poulem, Wheaton College.

11.15 A.M. "Chemistry for Boys and Girls"—Shipley W. Ricker, Woburn High School.

11.45 A.M. Experiments and Demonstrations—New Apparatus Committee, Earl S McColley, *Chairman*.

12 M. Business meeting.

12.30 P.M. Lunch.

Immediately after lunch the members of the association and friends were invited to a special performance of "Much Ado about Nothing" by the Wheaton College Dramatic Association.

University of Maryland. Dr. M. S. Kharasch, professor of organic chemistry at the University of Maryland, will address the South Jersey Section of the A. C. S. at Penns Grove, N. J., on December 2nd. His subject will be "The Potential Gradient of Organic Radicals and the Applications of It in the Interpretation of Organic Reactions."

Cornell Section, A. C. S. The Cornell Section of the A. C. S. met Wednesday, October 21st at 8.00 P.M. in Baker Laboratory. The feature of the meeting was a lecture by W. D. Bancroft on "Methods of Research." A discussion of the subject followed the lecture.

State University of Montana. W. E. Caldwell, a graduate of the Montana State Schools of Mines, was appointed graduate assistant in the chemistry department for the current year.

A psychological test was given to all University freshmen on October 14th. This test is also being given by a number of other Universities of the country with the object of establishing a satisfactory "norm" for the test.

The University of Nebraska. Beginning September first the following promotions in the department of chemistry took effect: Assistant professor T. J. Thompson to associate professor; instructor R. C. Abbott to assistant professor; assistant professor Cliff S. Hamilton to associate professor; and assistant professor B. Clifford Hendricks to associate professor.

Doctor H. G. Deming employed his summer in a double task, that of revising his general chemistry text and laboratory manual and in work for A. D. Little and Co. of Boston. Doctor D. J. Brown has just published, through the

University of Nebraska Press, a manual for use of his class in quantitative analysis. Doctors Hendricks and Hamilton have brought out a pamphlet, "Outlines of Qualitative Analysis," for use with their second semester general chemistry students and a "Students' Laboratory and Study Guide" for students in their classes in beginning chemistry.

Changes in the personnel of the teaching corps of the department of chemistry brought in as new additions: Doctor Waldo Westwater as instructor from the University of California, Miss Annella Wieben as half-time instructor from the Northwestern University, Ralph Neilsen as fellow from the University of California and John F. Chambers, Edward F. Degering, Ralph Frazier, Bess F. Whitney, and Viola Jelenek as scholars.

University of Arizona. Assistant Professor H. W. Estill has been granted leave of absence from the University for one year. This time he will spend in graduate work at Johns Hopkins University where he has a fellowship in bio-chemistry.

Mr. Henry Eyring who holds the M.S. degree from the University of Arizona and who served as instructor in chemistry last year has been appointed a fellow in physical chemistry at the University of California where he is working for the Ph.D. degree.

Mr. O. E. Schupp who received the M.S. degree in chemistry from the University of Arizona last June, has been appointed instructor in chemistry for one year. At the close of this time he expects to go to one of the larger Universities for graduate work in chemistry. Mr. Schupp worked with Dr. T. F. Buehrer of the Department of Chemistry on the "Electrometric Titration of Iron and Copper by Chromous Chloride." This work has been accepted for publication by one of the chemical journals and will appear in the near future.

Mr. Robert Nugent received the M.S. degree from the University of Arizona in June and has gone to Oxford University as a Rhodes Scholar. Under the direction of Dr. L. E. Roberts of the Chemistry Department, Mr. Nugent made a comparative study of the methods for determining magnetite.

Dr. Lila Sands who served as an instructor in chemistry at the University of Arizona last year has been promoted to an assistant professorship in biochemistry and has returned to Tucson from the University of Chicago. Dr. Sands was offered an assistant professorship in one of the large mid-western universities recently, but in view of the unique opportunities for research in certain special branches of chemistry at the University of Arizona, she declined the offer and will remain at Tucson.

University of Montana. Four recent graduates of the Chemistry Department of the State University of Montana are in the graduate schools of the country: L. B. Beckwith and R. E. Jackman are at Minnesota; H. M. Kvalnes is at California, and W. M. Koch at Illinois.

It is part of the stated policy of this Department to encourage only the best students to continue as chemistry majors and to urge these to do graduate work.

N. E. O. T. A. The first meeting of the year 1925–26 of the chemistry teachers of Northeastern Ohio will be held in Akron, December 12th. The report of the testing committee will be given in detail and at least two other committees are ready to report. Important matters of a business nature will be brought up. Vernon S. Culp, West High School, Akron, Ohio, will have charge of the arrangements for the meeting and any chemistry teachers who have not been notified by the committee can communicate with Mr. Culp.

Nature alone is always true to herself; she alone through the ages never lies, never changes, never hesitates, ever presses onward.—EDEN PHILLPOTTS

Recent Books

Chemistry in Everyday Life. EMERY, DAVIS, BOYNTON, AND DOWNEY. Lyons and Carnahan, Chicago, 1924. xiii + 667 + xlix pp. 13.5 × 18.5 cm. $1.76 postpaid.

This text is by no means a small one as one can judge by the number of the pages, nor is it brief in substance. It is one of the most comprehensive texts that has come to the attention of the reviewer. Because of its heavily sized paper, the shape of the book, the plain appearance of the text, the first impression is likely not to be one of approval; but after noting how flat the book opens and how easily the text reads because of the good type and the simple arrangement, and more especially after careful scrutiny of the contents, one is constrained to classify it among the more successful of recent chemistry texts. There is very little of elementary chemistry that the authors have omitted.

Many of the modern chemistries are written with the idea of furnishing a ready means for passing college entrance examinations. The means for this are furnished in the first 393 pages of the text, but the book contains other instructive material on the chemistry of everyday life.

The selection of the material of the text as well as its arrangement seems to have been based on reports received from chemistry teachers throughout the United States.

There are 218 illustrations, a complete index, and 65 tables. Special topics number 269 pages.

Chemical equations are used beginning with the first chapter but the method of writing equations is not explained until page 140 is reached. The wisdom of deferring the explanation of equation writing so long is questionable.

The arrangement of the index whereby topics are listed by section numbers rather than by pages is annoying. Also the fact that uniformly large type is not used for all sections, leads to a search over the page for the smaller printed section number. Look up "molecular weights" for instance. It is found under section 56—this number printed in *small* type and followed by the word "problems." So it is with "Avogadro's Hypothesis" and other topics. The following section numbers show how scattered the very meager material on some of the fundamental laws and hypotneses of chemistry is: 15, 56, 191, 353. The authors state that all the text need not be studied by the student indicating perhaps that there is some irrelevant matter, but the reviewer believes that a closer following of the authors of some of the recent chemical texts as to their content on law and theory, would be far more satisfactory.

Each chapter has its quota of problems—not too many and not too difficult for beginners, who are also assisted by being shown the equations involved in the problem.

The reviewer believes that the book, generally, shows the usual earmarks of being written by several authors, indicated by an apparent lack of coherence in the text taken as a whole and more apparently by the lack of personality in its style. The reviewer has in mind a certain other chemistry text where the phraseology and diction of the single author amount almost to a charm, leading to phenomenal popularity for the text.

As to illustrations in the present text they show good choice, originality, and they are up-to-date, but the character of the cuts, the different intensities of the lights and shadows, present a rather motley appearance as the pages are scanned.

It is thought that perhaps too great effort has been made to please chemistry teachers throughout the land and to combine an elementary text with a general treatise on chemistry. However, the book indicates a great amount of labor and thought and care in its preparation and the authors are to be congratulated on the product, but a second and revised edition ought to make a more serviceable text.

J. HOWARD GRAHAM

Applied Chemistry. A Laboratory Manual. EMERY, MILLER, AND BOYNTON. Lyons and Carnahan, Chicago, 1924. 115 experiments. 19 × 26.5 cm. $1.40 postpaid.

The authors say "that the order of experiments follows closely the arrangement of the text by the same authors, but that the experiments are of such a nature that they may be used with any well-constructed text." The experiments fall into four parts, 47 of general inorganic, 52 of food experiments intended chiefly for girls of domestic science courses, 14 experiments of a more technical nature than the first 47, and finally a brief system of inorganic analysis.

This book of laboratory experiments is a very handy one. By means of a cord and snaps it can be opened flat or closed so as to hold all pages securely.

The experiments are of the usual type found in laboratory manuals of chemistry but an attempt has been made to direct the pupil so as not to require for him too much supervision by the teacher. All necessary drawings are made for the pupil and typical equations are written, but blank spaces are left to be filled with answers and

equations. The idea is to have the teacher grade the pupil on the actual chemistry content of the written reports and not on the quality of his drawings nor on the neatness of arrangement, etc.

The first pages of the manual have lists of the experiments, general directions for treatment of accident cases, and lists of apparatus illustrated with excellent drawings. These are all good features.

Altogether it is a very commendable combination of manual and note-book and ought to render extensive service in the schools.

J. HOWARD GRAHAM

Lecture and Laboratory Experiments in Physical Chemistry. HENRY S. VAN KLOOSTER, Ph.D. Second Edition of **Lecture Demonstrations in Physical Chemistry.** The Chemical Publishing Co., Easton, Pa., 1925. x + 274 pp., 91 figures. 13 × 19 cm. $3.00.

Professor van Klooster has brought together in this book three hundred and sixty experiments in general physical chemistry, most of them expressly adapted for use in lecture demonstrations. The book is issued as the second edition of the author's "Lecture Demonstration in Physical Chemistry." "The chapters on catalysis, electrochemistry and ionic theory, solubility, colloid chemistry, and adsorption have been enlarged, and two new chapters dealing with radio-activity and miscellaneous experiments added. About one hundred new experiments have been described." (Preface.)

The experiments cover most of the subjects commonly included in elementary physical chemistry, as well as many of the topics that may well be used in connection with courses in general chemistry. The directions are given with sufficient detail to be really useful, and the numerous references to original sources are a valuable feature of the work, as anyone who has had much experience in trying to demonstrate experiments from second- and third-hand descriptions will agree.

The author does well to emphasize the importance of lecture demonstrations in physical chemistry, and it is indeed striking, as he suggests, to note how large a proportion of the experiments is due to the famous teachers of the subject. The book under consideration should be a great aid in stimulating further efforts to improve the teaching of physical chemistry. Because of the increasing prominence of physical chemistry in general-chemistry courses, the book should be of value also to teachers of such classes.

G. H. CARTLEDGE

Quantitative Analysis. JAMES M. HENDEL, Assistant Professor of Chemistry, Hunter College of the City of New York, Ginn & Company, Boston, Mass., 1925. vi + 134 pp., 13 × 19 cm., $1.40.

This little book is evidently written for Dr. Hendel's classes in Hunter College. It contains eleven chapters; Weighing, Simple Gravimetric Principles, General Theory of Gravimetric Procedures, Practical Analysis of a Dolomitic Rock, Volumetric Methods and Apparatus, Alkalimetry and Acidimetry, Oxidation and Reduction Methods, Iodimetry, Electric Methods, Errors, and the Precision of Analytical Results.

The selection of samples discussed is conventional. As a text-book, it could well be supplemented by a systematic course of lectures.

The last chapter of the book on errors and the precision of analytical results, though brief, is to be commended. It is to be hoped that in later editions, the book may be considerably expanded.

VICTOR LENHER

How to Teach General Science, Notes and Suggestions of Practical Aid to Every Science Teacher. J. O. FRANK, Professor of Science Education in the Wisconsin State Normal School at Oshkosh. Castle-Pierce Press, Oshkosh, Wis., 1925. xiii + 194 pp. 13 × 19 cm. $2.00.

This book was brought to print after having been taught in manuscript form to more than two hundred teachers. One cannot read it without noting a refreshing directness and conciseness of style, and a richness of suggestion that is inspiring. The book is closely written and splendidly organized, and equipped for the utmost practical aid of any general science teacher from youngest to oldest with abundant up-to-the-minute topic references.

The author briefly surveys the development of schools and teaching to clear away any confusion as to the real place of general science in secondary education. Then follows a justification of his theories in citations from the findings of modern educational psychology and in the conclusions of the N. E. A. special committees as to broad aims, which the author simplifies and sums up for general science teaching as: "In the grades, to furnish experience. . . . . as tools for later understanding. . . . In the Junior High School, to discover dominating interests. . . . . In the Senior High School to carry his dominant interests to intellectual independence." General science should not be thought of as a reservoir of unlimited facts of "Science" (and everything else), but as a fund of practical appealing matter, rigidly selected from the stand-point of accepted aims to be the vehicle for teaching some fundamental principles of science, habits of accuracy and observation, and for training in "how to study and how to learn."

Consideration of legitimate subject-matter leads to the conclusion that "an ideal text-book for universal use is impossible;" but the scheme for three levels of subject-matter seems to offer a much-needed solution of this want. The chapter on general science references is complete, and "Special Teaching Aids" appears to be a veritable

Pandora's box of *good* things in which every science teacher may revel. Chapters on "Science Methods," on other special methods and technique, and on "Measurement of Results" are presented in a very fair pro and con treatment for comparative evaluation, which together with a thorough analysis of the leading phases of the profession, places squarely before the teacher the essentials of his problem in general science.

If this book is studiously read by the teachers of general science of the country it will mark an epoch in the standardization of matter and stabilization of methods in the subject, and will undoubtedly bring to realization its broadest appeal which as the "little brother" of the special sciences really seems to be its mission, *viz.*, "to impart a certain body of knowledge—fairly uniform throughout the country—which will mark the American individual wherever he goes. This is a necessity in a democracy like ours—in an age of science."

M. F. WADLEIGH

Teaching Science in the Schools. ELLIOT ROWLAND DOWNING, The School of Education, University of Chicago. The University of Chicago Press, Chicago, 1925. xiii + 185 pp. 12 illustrations. 13.7 × 19.3 cm. $2.10 postpaid.

The book under review is logically the first of the sub-series, "The Teaching of Science" in the general "University of Chicago School Science Series." Another volume of this sub-series was published about a year ago upon "The Teaching of General Science." Doctor Downing's volume, as the introductory publication, "summarizes the most important results of the scientific study of the problems of science-teaching and their application to the broad field of science instruction."

The table of contents lists such chapter headings as: Science-Teaching of the Past; Science-Teaching of the Present; Relations of Science-Teaching to the Social and Economic Past; Science as a Curriculum Subject; Aims of Science-Teaching; Content of School Sciences; Organization of School-Science Content; Methods of Teaching Science; Tests of Science-Teaching; and Science-Teaching in European Schools.

High points of the book are largely found in the summarization of results of many studies of science-teaching. As an instance: "since 1890 there has been a greater increase in the percentage of students enrolled in science in the high schools than in any other subject and the present enrolment in science is greater than in any other subject."

An analysis of present conditions is given that should greatly aid a science teacher to orient and standardize his own efforts. Enrolment tendencies in different science subjects, the distribution of the different subjects in the curriculum, the teaching load of the science teacher, and the costs of secondary science instruction are among the elements of this analysis.

The author not only gives his own aims of science instruction but compiles such aims from various sources and by an analysis of them shows that their apparent variance from each other disappears upon closer study. These aims are shown to be supplements to each other and to be in reality "mutually inclusive."

The problem of science content is studied first in terms of child and public interest. Results of such studies are reported as a basis for the use of this principle. The other two principles used are; the material should be socially worthwhile, and it should most readily lend itself to the aims of science instruction.

This volume also gives one of the first compilations of studies made in an effort to determine the relative efficiencies of the text-book, the lecture-demonstration, and the laboratory methods of science instruction. For some readers it may appear that undue space is given to the "Unit method" of instruction which seems to be in much favor with the author.

The part treating "Tests" describes the process of developing and standardizing tests; discusses different types of tests and points out where there is need of types of tests not yet available. A good bibliography upon specific tests for high-school sciences is given.

Two chapters impress the reader as being below the impersonal level of the remainder of the book. Principles of organization are those of the author without reference to or comment upon anything of the sort previously put forth. Science-teaching in European schools impresses one as being an afterthought; interesting and helpful but not a vital, supporting part of the purpose of the book.

The chemistry teacher will find his subject given its proportionate part of the space throughout the different chapters. This is an evidence of balance deserving of note for the author is a biologist and would unconsciously tend to turn to those subjects for illustrative materials. Four major illustrations are from studies using chemistry classes as a basis. The next volume in the series is to be "The Teaching of High-School Chemistry."

B. CLIFFORD HENDRICKS

TO BE REVIEWED LATER

General Chemistry, 2nd Edition—Deming.

Physiological and Clinical Chemistry—Pearson & Hepburn.

Leitfaden der Gegenwartschemie fur Höhere Schulen—Meyer.

Fundamentals of Physical Chemistry—Eucken.

Inorganic Quanitative Analysis—Fales.

The Teaching of Science and the Science Teacher—Brownell and Wade.

A FEW MOMENTS WITH THE BUSINESS MANAGER

Beaumont, Tex.,
October 5, 1925

It is a pleasure to thus invest my money. Several times has the man in charge of Physics here remarked that he sure wished a similar journal was published for his work. I never fail to say a good word for the JOURNAL.

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Chemistry Dept.,
Iowa State College

Helena, Mont.,
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I enjoy your magazine very much and I believe it fills a much needed position. It is indispensable to anyone who wishes to keep up with events in the chemical world.

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Very truly yours,
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